EOS Ground System (EGS) System and Operations Concept

June 1996

Earth Science Data and Information System (ESDIS) Project
Goddard Space Flight Center
National Aeronautics and Space Administration

Preface

This document is final and complete. It is provided for information purposes and is not under ESDIS Project Configuration Control.

Questions concerning this document or proposed changes should be addressed to

Daniel S. Devito
System Engineering Manager
Code 505
Goddard Space Flight Center
Greenbelt, Maryland, 20771

Abstract

The EOS Ground System (EGS) System and Operations Concept presents an end-to-end view of EGS operations. It provides a unified description of the activities performed by the EGS elements, with major emphasis on the elements of the EOS Data and Information System (EOSDIS). It has been prepared as a companion to the Earth Science Data and Information System (ESDIS) Project level 2 requirements, and is intended to assist EOS investigators and other users in understanding EGS capabilities and user interfaces and to aid developers of the EGS elements in interpreting the level 2 requirements. It is also intended to support the ESDIS Project and its component projects in evaluating the operational feasibility of the planned evolution of the EOSDIS, and in assessing the impact of proposed changes to EOSDIS requirements and designs at all levels.

Keywords: CSMS, DAAC, EBnet, ECS, EDOS, EGS, EOS, EOSDIS, EOS Ground System, ESDIS Project, ETS, FOS, Mission Operations, Monitoring and Coordination, MTPE, Science Data Operations, Version 0

Contents

Preface

Abstract

Section 1. Introduction

Section 2. EOS Mission Overview

Section 3. EGS Description

Section 4. EGS Operations

Figures

Tables

Abbreviations and Acronyms

Glossary

Section 1. Introduction

1.1 Purpose

The purpose of the *Earth Observing System (EOS) Ground System (EGS) System and Operations Concept* (ESOC) document is to present an end-to-end view of EGS operations. This document provides a unified description of the activities performed by the EGS elements, with major emphasis on the elements of the EOS Data and Information System (EOSDIS).

This document is intended to assist EOS investigators and other users in understanding EGS capabilities and user interfaces, and to aid developers of EGS elements in interpreting the level 2 requirements. It is also intended to support the Earth Science Data and Information System (ESDIS) Project and its component projects in evaluating the operational feasibility of the planned evolution of the EOSDIS, and in assessing the impact of proposed changes to EOSDIS requirements and designs at all levels. This document is not intended to dictate design decisions at any level of implementation.

1.2 Scope

The scope of this document is limited to a level 2 operations concept that is responsive to ESDIS Project level 2 requirements and to the companion interface requirements documents and memoranda of understanding. This document is intended to supplement the *EOS Mission Operations Concept* and the *EOS Science Operations Concept* by providing a description of EGS operations as they support the flight and science missions. The level of detail provided in this document is consistent with the ESDIS Project level 2 requirements.

The descriptions presented in this document are based on nominal operations for the AM-1 mission. However, the scenarios presented are generally applicable to all EOS missions, and can be updated for multi-mission operations.

1.3 Organization and Contents

This document contains four sections, a list of abbreviations and acronyms, and a glossary.

Section 1 defines the document's purpose and scope; describes its organization and contents; identifies the assumptions and conventions used in preparing it; and lists other documents relevant to its contents.

Section 2 presents an EOS mission overview, to place the EGS in the context of the National Aeronautics and Space Administration’s (NASA’s) Mission to Planet Earth (MTPE) and the EOS Program. The EOS Program mission objectives and principal mission requirements are presented, the major EOS segments and international participation in the Program are briefly described, and the general operations concept for EOS missions is summarized.

Section 3 describes the EGS. It presents the goals and objectives, key requirements, and a reference architecture. The EGS components and capabilities are described, and the implementation approach and evolution of operations capabilities are discussed.

Section 4 describes EGS operations. It discusses mission operations, science data operations, EGS monitoring and coordination, and operations support. The functions and processes that comprise each category of operations are described at a summary level.

1.4 Assumptions and Conventions

The concepts presented in this document are intended to be consistent with the operations concepts defined for the EGS elements. The descriptions and scenarios presented in this document use elements from the design of each system to indicate where specific functions are expected to reside, in order to explain the processes under discussion.

The terminology used in this document is consistent with that used in EOS Program and ESDIS Project documents. Where applicable, specific terms used in relevant documents prepared by EGS system projects have been adopted to retain the level of precision provided in those documents.

Editorial conventions used in this document are consistent with the *Specification for Document Formats*, with the following exceptions:

a. Use of acronyms:
   1. Acronyms are spelled out on the first use in each section, except for MTPE, EOS, EOSDIS, the EOSDIS elements and their components, and United States (U.S.) government agencies and international partner organizations; these are spelled out only on the first use in the document.
   2. Acronyms for spacecraft instruments are not spelled out in the text; full spell-outs are provided in the acronym list.
   3. For words that have acronyms that would be used only once in this document, the acronym is not noted either in the text or in the acronym list.
   4. Acronyms used in figures and tables but not in the text are included in the acronym list; they may or may not be spelled out in the graphics.

b. To facilitate future updates to this document, all figures and tables are numbered according to the section or major subsection in which they are presented (e.g., Figure 4-1, Figure 4.1-1, and Figure 4.2-1 vs. Figure 4-1, Figure 4-2, and Figure 4-3).
c. To assist the reader in differentiating between specific documents and categories of documents, the titles of individual documents called out in the text are italicized (e.g., *EOS Mission Operations Concept* [specific document] vs. operations concept documents [category of documents]).

1.5 Applicable Documents

1.5.1 Precedence

In case of differences between this document and the documents listed below, the latest versions of the documents listed in Sections 1.5.2 and 1.5.3 take precedence over this document.

1.5.2 Requirements

a. 170-01-01, Revision A, *Execution Phase Project Plan for Earth Observing System (EOS)*, May 1995
b. *Earth Science Data and Information System (ESDIS) Project Level 2 Requirements*
   1. 423-10-01-0, Volume 0: Overall ESDIS Project Requirements, February 18, 1993

2. 423-10-01-1, Volume 1: EOSDIS Core System (ECS), May 21, 1993
3. 423-10-01-2 (previously GSFC 423-35-01), Volume 2: EDOS and Ecom Requirements, March 17, 1992
4. 423-10-01-3, Volume 3: Other ESDIS Project Requirements, October, 1995
5. 423-10-01-5, Volume 5: EOSDIS Version 0, September 13, 1993
6. 423-10-01-6, Volume 6: EOSDIS Backbone Network (Ebnet) Requirements, December, 1995

1.5.3 Operations Concepts

a. GSFC/MO&DSD, *EOS Mission Operations Concept Document*, June 1995
b. STX/EOSDIS 91-01, *EOS Science Operations Concept*, December 1991
c. 604-CD-001-003, *ECS Operations Concept for the ECS Project: Part 1 - ECS Overview*, June 1995
d. 604-CD-002-003, *Operations Concept for the ECS Project: Part 2B - ECS Release B*, March 1996
e. 604-CD-004-001, *ECS Operations Concept for the ECS Project: Part 2, FOS,* October 1995
f. 560-EDOS-0106.002, *EOS Data and Operations System (EDOS) Operations Concept*, December 18, 1992 (with DCN 006, March 15, 1995)
g. 515-3OCD/0194, *EOSDIS Test System (ETS) Operations Concept* (Review), May 1995
h. (no document number), *Mission Operations Concept Document for the Landsat 7 Ground System*, July 1995
i. TRMM-490-080, *Tropical Rainfall Measuring Mission Operations Concept,* July 1993

1.5.4 Other Documents

a. *EOS Ground System Architecture Description Document (ADD*), June 1996
b. (no document number), *ESDIS Project Project Management Plan* (2nd Draft), February 27, 1995
c. NASA NP-215, MTPE *EOS Reference Handbook*, 1995
d. 560-EDOS-0211.0001, *Interface Requirements Document (IRD) between the EDOS and the EOS Ground System (EGS) Elements*, December 18, 1992 (with DCN 006, April 17, 1995)
e. 500-TIP-2110, *Specification for Document Formats*, August 1992 (Revision 1)

Section 2. EOS Mission Overview

The Earth Observing System (EOS) -- a series of polar-orbiting and low-inclination satellites for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans -- is the centerpiece of MTPE. In tandem with EOS, the polar-orbiting and mid-inclination platforms from Europe, Japan, and the U.S. National Oceanic and Atmospheric Administration (NOAA) form the basis for a comprehensive International Earth Observing System (IEOS).

2.1 Mission to Planet Earth

Scientific research shows that the Earth has changed over time and continues to change. MTPE is NASA's contribution to the U.S. Global Change Research Program (GCRP). The GCRP will establish a basis for national and international policy regarding possible changes in the Earth's climate; the overall purpose of MTPE is to determine the extent, causes, and regional consequences of these changes. NASA's research efforts are primarily focused on space-based studies of the Earth as an integrated system, to provide the scientific basis for understanding global change.

MTPE is an evolutionary program composed of two mission phases. Phase I consists of observations from ongoing and near-term satellites operated by NASA, other U.S. agencies, and international partners to provide data for use in monitoring the global climate and other Earth system processes that lead to global change. The Tropical Rainfall Measuring Mission (TRMM) and the Landsat 7 spacecraft are included among the large number of Phase I missions. Numerous air and ground observations of the Earth will also be performed during Phase I. During Phase II, the global observations of Phase I will continue and will be augmented by more coordinated and comprehensive observations from spacecraft of the various EOS series over a 20-year period.

2.2 EOS Program Mission Objectives

The goal of the EOS Program is to advance scientific understanding of the entire Earth system on a global scale, by developing a deeper understanding of the components of that system, the interactions among them, and how the Earth system is changing. The program's objectives in support of this goal are

a. To create an integrated scientific observing system emphasizing climate change, to enable multi-disciplinary study of the Earth's critical, life-enabling, interrelated processes involving the atmosphere, oceans, land surface, polar regions, and solid Earth, and the dynamic and energetic interactions among them.
b. To develop a comprehensive data and information system, including a data retrieval and processing system, to serve the needs of scientists performing an integrated multi-disciplinary study of the Earth and to make MTPE data and information publicly available.
c. To acquire and assemble a global data base for remote sensing measurements from space over a decade or more, to enable definitive and conclusive studies of Earth system attributes.

2.3 Principal EOS Mission Requirements

The principal EOS mission requirements are to:

a. Establish a spaceborne observation capability lasting over 20 years.

b. Maintain continuity of essential global change measurements from ongoing and planned missions.
c. Obtain at least one decade of overlapping, calibrated data from the full EOS space system.
d. Characterize the highly variable aspects of the Earth's global system every one to three days.
e. Make all NASA Earth science data readily and promptly available.
f. Support the communication and exchange of research findings based on EOS data or produced by EOS investigations.
g. Support the overall U.S. GCRP.

EOS mission requirements also include general level 1 requirements to meet standards in communications and data delivery; provide capabilities for science investigation, end-to-end system testing, and international technology transfer; and minimize the generation of orbital debris.

2.4 Major EOS Segments

EOS consists of three major segments: a space system, a ground system, and an integrated scientific research program.

a. The space system provides new capabilities for acquiring global Earth sciences data.
b. The ground system, primarily the EOSDIS, makes the full suite of EOS and other NASA Earth science data accessible to the broad science/user community.
c. The integrated scientific research program uses data from EOS and non-EOS missions to investigate the Earth system.

Figure 2.4-1 represents the relationships among these segments.

2.4.1 Space System

The EOS space system consists of a series of predominantly polar-orbiting spacecraft. The United States, the European Space Agency (ESA), and Japan's National Space Development Agency (NASDA) are scheduled to fly EOS missions. The EOS-era missions currently planned are shown in Table 2.4-1.

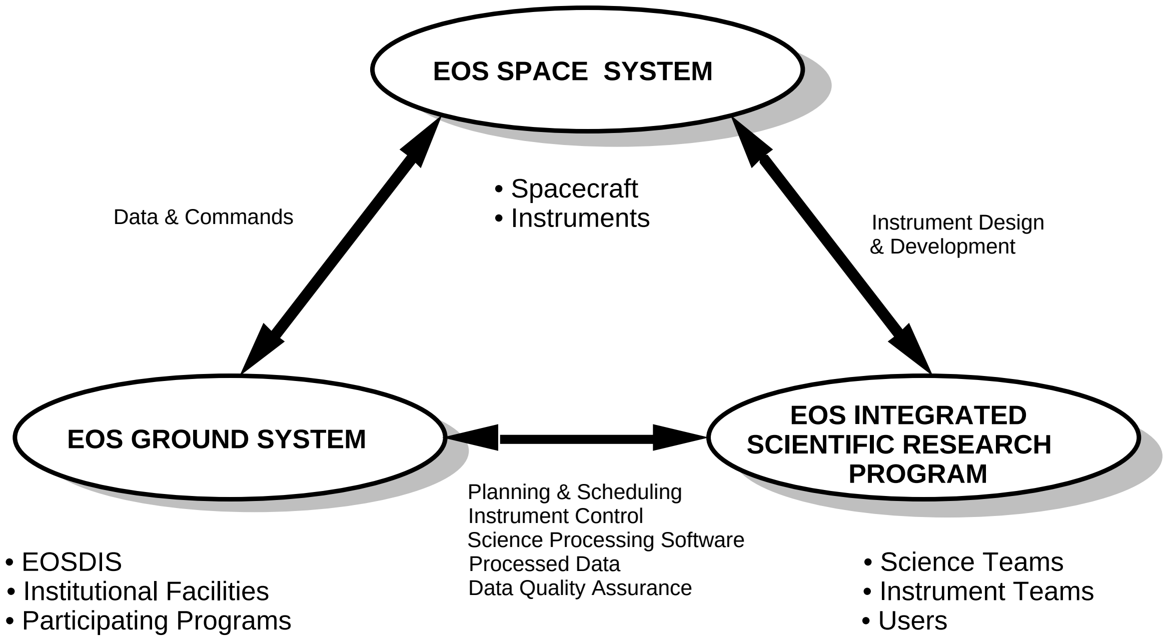

Figure 2.4-1 Major EOS Segments

Table 2.4-1 Planned EOS-Era Missions

Country	Program	Spacecraft	Launches (Tentative)
United States	Earth Observing System (EOS)	AM series	1998, 2004, 2010
		PM series	2000, 2006, 2012
		LALT series	2003, 2009, 2015
		CHEM series	2002, 2008, 2014
ESA	Polar-Orbit Earth Observation Mission (POEM)	ENVISAT series	1998
		METOP series	2000
Japan	Japanese Earth Observing System (JEOS)	ADEOS IIA	1999
		ADEOS IIB	to be scheduled
		TRMM-2	2000

Four series of U.S. EOS spacecraft are planned, each with a different flight configuration based on scientific measurement objectives. During EOS's projected 20-year operational lifetime as many as four spacecraft (one from each series) may be operating simultaneously. In addition, two spacecraft from the same series may be in orbit during a spacecraft cross-over replacement period of up to six months. The major science objectives for each series is shown in Table 2.4-2. More detailed

Table 2.4-2 Summary of EOS Science Objectives

Series	Major Science Objectives
AM	Characterization of the terrestrial and oceanic surfaces
	Clouds, aerosols, and radiation
	Radiative balance
	Sources and sinks of greenhouse gases
PM	Cloud formation, precipitation, and radiative balance
	Terrestrial snow and sea ice
	Sea-surface temperature and ocean productivity
LALT	Ice sheet mass balance
CHEM	Atmospheric chemical species and their transformations

information about each series is provided in the *Execution Phase Project Plan for Earth Observing System (EOS)* and in the documentation associated with each mission.

The scientific instruments for the NASA EOS spacecraft are divided into two instrument classes, facility and principal investigator (PI). Facility instruments measure variables useful to a wide range of science disciplines; PI instruments observe more specific phenomena. Many instruments have been selected or are in
the process of being selected to be flown on the U.S. EOS series of spacecraft. In addition to these EOS spacecraft, EOS-funded Flight of Opportunity instruments will be flown on other U.S. and international spacecraft. For details about the EOS instruments, see the *1995 MTPE EOS Reference Handbook*.

The AM-1 spacecraft will use the Space Network (SN) Tracking and Data Relay Satellite System (TDRSS) as the primary space-to-ground communications link. It will also have an X-band capability that will be used in the event of a failure in the primary communications link. For all subsequent NASA EOS spacecraft, the primary communications link will be an X-band downlink to dedicated EOSDIS ground stations. The X-band sites will also provide S-band command and control links, although all EOS spacecraft will retain capabilities for using the SN for command and control purposes. EOS spacecraft will utilize the Deep Space Network, Ground Network, and Wallops Orbital Tracking Station for emergency communications.

The *EOS Mission Operations Concept* provides a more detailed discussion of EOS instrument complements, flight configurations, launch and spacecraft orbits, spacecraft design concepts, and space-to-ground communications.

2.4.2 Ground System

The EOS Ground System (EGS) is an operational assembly of facilities, networks, and systems which collectively comprise the infrastructure necessary to acquire, transport, archive, process, distribute, and organize EOS and other NASA Earth science data and make it accessible to the broad science/user community. The EGS comprises EOS program-specific components and capabilities called the EOSDIS, and institutional service providers and other participating programs that are not solely dedicated to the EOS program. Figure 2.4-2 identifies the EGS elements that make up the EOSDIS, and the EOSDIS interfaces with the remaining EGS elements. The role of each element is summarized in Table 2.4-3, and further discussed in Section 3.1.

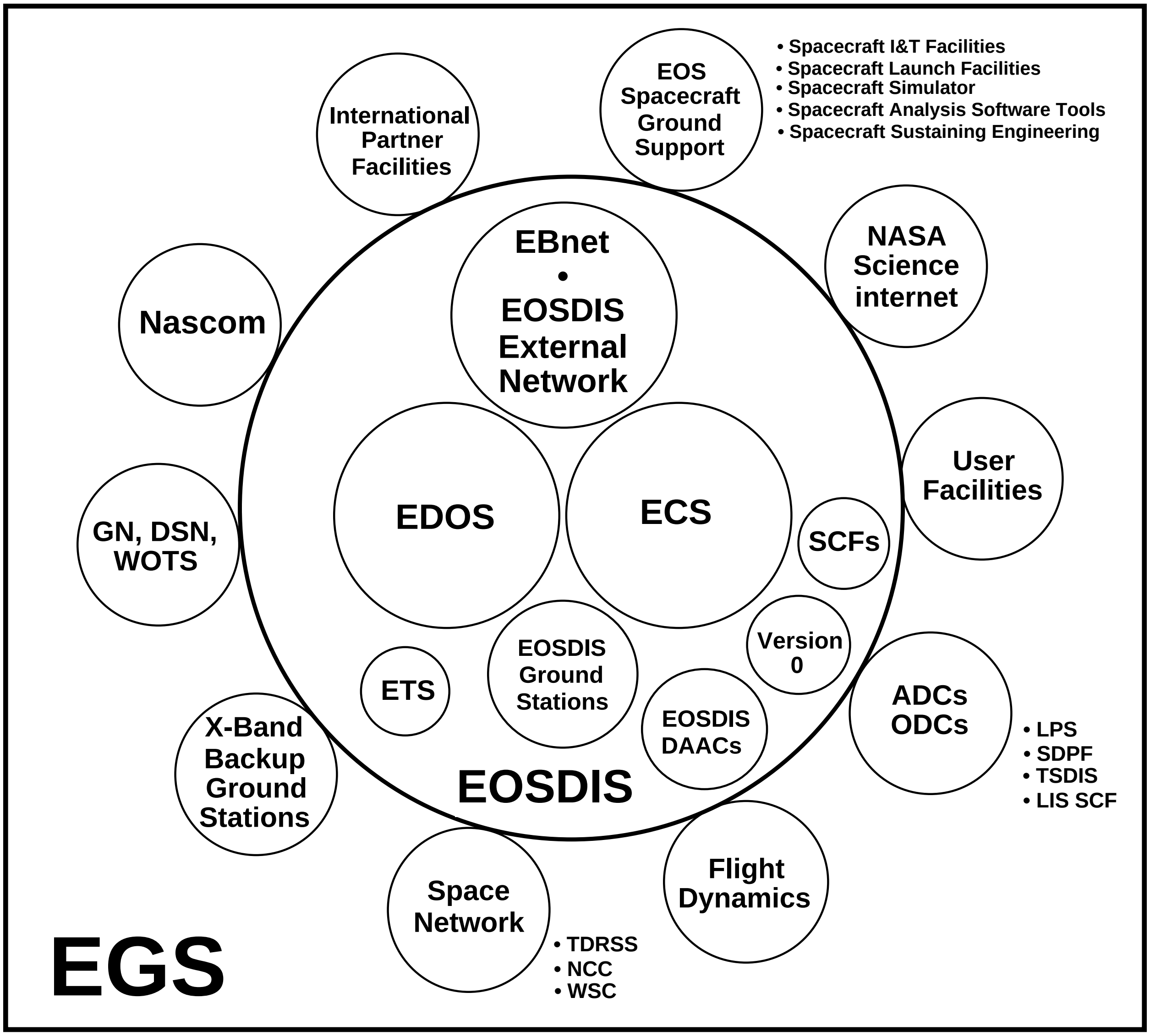

Figure 2.4-2 EOS Ground System Elements and EOSDIS Interfaces

Table 2.4-3 Summary of Roles of EGS Elements

EGS Element	Role
EOSDIS	
• EOSDIS Core System (ECS)	Provides EOS flight operations; science data processing; and EOSDIS communications and system management
• Distributed Active Archive Centers (DAACs)	Provides production, archive, and distribution of EOS and non-EOS science data products, and user support
• Version 0	Provides a working prototype of selected key EOSDIS services with some operational elements
• Science Computing Facilities (SCFs)	Provides science data processing software/algorithms, data product quality assessment, and user support
• EOS Data and Operations System (EDOS)	Provides EOS data capture, level 0 processing, and backup archive
• EOSDIS Backbone Network (EBnet) and External Network	Provides EGS mission operations communication services and science operations communication services
• EOSDIS Test System (ETS)	Provides test data generation and EGS element simulation capabilities
• EOSDIS Ground Stations	Provides space to ground communications services for post-AM-1 missions
Institutional facilities	
• Flight Dynamics	Provides orbit and attitude data, and orbit adjust and maneuver computations for EOS spacecraft
• Nascom	Provides communications services between the White Sands Complex (WSC) and EGS elements
• Space Network	Provides TDRSS services for AM-1 spacecraft; coordinates other ground station scheduling
• Ground Network (GN), Deep Space Network (DSN), Wallops Orbital Tracking Station (WOTS)	Provides backup low-rate communications services
• X-Band Backup Ground Stations	Provides backup science data communications services for AM-1
Participating Programs	
• EOS Spacecraft Ground Support	Provides real-time spacecraft simulations, generation and test of flight software updates, integration and test facilities, operational launch support services, and spacecraft sustaining engineering facilities and services
• International Partner Facilities	Includes interfaces with international partner facilities such as the ASTER Ground Data System (GDS), and the NASDA Earth Observation Information System (EOIS)
• Affiliated Data Centers (ADCs) & Other Data Centers (ODCs)	Provides selected Earth science data and metadata to DAACs for archive and user access; examples include the Landsat Processing System (LPS), and the TRMM Science Data and Information System (TSDIS)
• User Facilities	Provides user access to EOSDIS science data
• NASA Science Internet (NSI)	Provides external communications services between EOSDIS and EOSDIS users

2.4.3 Integrated Scientific Research Program

The EOS integrated scientific research program is comprised, in part, of a large, geographically distributed science user community. Scientists determine the observations to be made; instrument engineering teams build the instruments to collect the data; science teams plan and schedule the use of the instruments; and science users provide the EGS with the science algorithms for generating data products and evaluating the quality of the generated products. Finally, scientists analyze the data from the EOS instruments, publish research results, and make recommendations to the global change research community.

EOS users, who represent a broad range of science disciplines, operations experience, and computer systems skills, are divided into three categories. The first category, EOS investigators, consists of the investigators and research staff under contract with NASA to participate in the EOS program. This group includes the PIs and co-investigators associated with the PI-class instruments, the team leaders and team members associated with facility instruments, and the interdisciplinary investigators associated with two or more instruments. The second category consists of the large group of non-EOS affiliated science users, such as U.S. and international science researchers located at various government agencies, educational institutions, and commercial organizations. The third category constitutes a more diverse group of users who are expected to use EOS and other MTPE data for purposes other than science investigations or research. These purposes include, for example, policy-making; the operation, maintenance, and management of the EGS; commercial applications; and education.

2.5 International Participation

Because the EOS Program is part of a global effort, the participation of international users and organizations is important in all phases of EOS activities. U.S. scientists work closely with their international counterparts in planning the World Climate Research Program (WCRP) and WCRP specialized global research programs that are central components of the U.S. GCRP. The Earth Observations International Coordination Working Group is the forum within which the U.S., Europe, Japan, and Canada discuss, plan, and negotiate the international cooperation essential for implementation of the IEOS Program.

Several foreign space agencies, including ESA, the Canadian Space Agency, Japan's NASDA, and the European Organization for the Exploitation of Meteorological Satellites, are planning Earth observing missions that complement the NASA EOS program. As part of this cooperative effort, international instruments will be flown on U.S. EOS spacecraft and U. S. instruments will be flown on international spacecraft .

2.6 General Operations Concept

The mission life-cycle for each EOS spacecraft includes five phases: prelaunch, launch, activation, mature operations, and cross-over operations and deactivation. This section describes a general operations concept for EOS missions during the mature operations phase of the mission lifecycle. Figure 2.6-1 presents a high-level view of the EOS mission general operations concept in terms of the following major ground system functions.

a. Spacecraft command and control,
b. Data capture and level 0 processing,
c. Science data processing, archiving, and distribution,
d. Communications and systems management, and
e. Data communications.

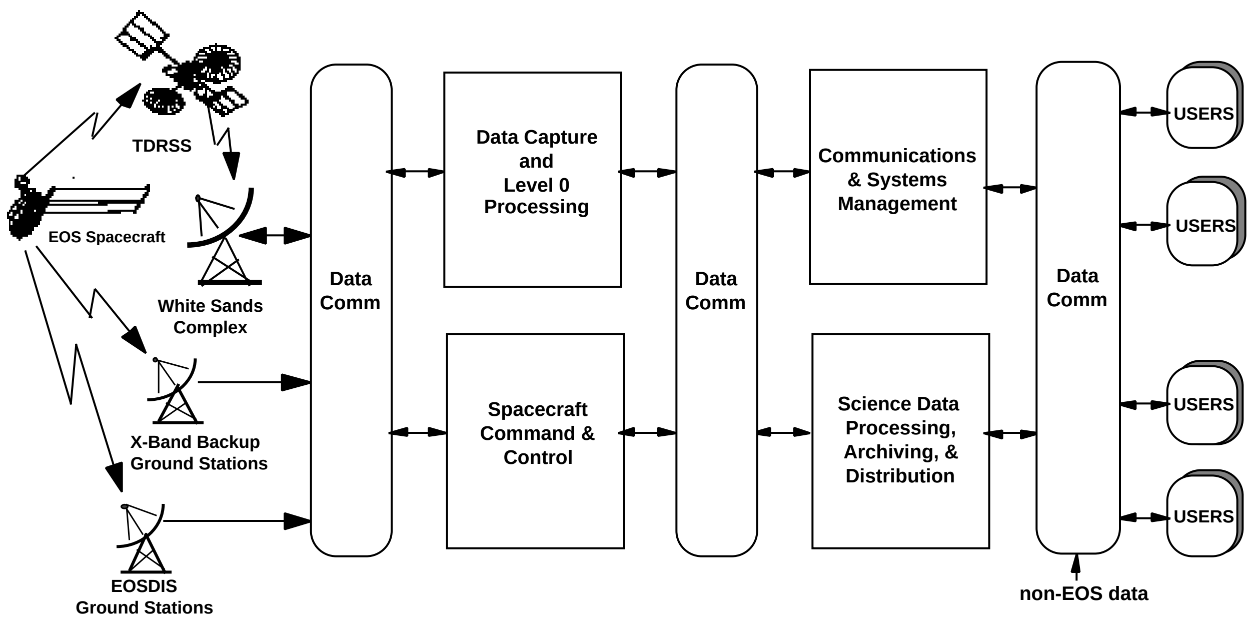

Figure 2.6-1 EOS Mission General Operations Concept

The activities illustrated in Figure 2.6-1 are performed during the mature operations phase for each EOS spacecraft. Communications with EOS spacecraft are accomplished through either the TDRSS or EOSDIS ground stations. The X-Band backup ground stations provide backup science data communications for AM- 1. The raw spacecraft data are captured, processed into a level 0 format, and stored in a backup archive. Level 0 data are transported to science data processing facilities, where standard data products and other special data products are produced, archived, and distributed to EOS investigators and other users via external networks and other interfaces. These facilities also ingest and archive non-EOS Earth science data to make these data available to investigators and support special product generation.

The EGS supports EOS mission operations by performing spacecraft and instrument command and control, including mission planning and scheduling and monitoring the health and safety of the spacecraft and instruments; and by providing internal communications and EGS status monitoring and coordination.

The EGS is discussed in more detail in Section 3. EGS operations are described in Section 4.

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Section 3. EGS Description

The EOS Ground System (EGS) is an operational assembly of facilities, networks, and systems which collectively comprise the infrastructure necessary to acquire, transport, archive, process, distribute, and organize EOS and other NASA Earth science data and make these data accessible to the broad science/user community. The EGS comprises the following:

a. EOS program-specific components and capabilities called the EOSDIS
b. Institutional facilities that provide services to multiple missions simultaneously, and
c. Other participating programs that are not solely dedicated to the EOS program.

This section describes these components that comprise the EGS in more detail, with primary emphasis placed on describing the role of the EOSDIS. Figure 3-1 presents an overview of the EGS with components of the EOSDIS depicted as shaded. A more detailed view of the hardware and software components, and the communications infrastructure of the EGS is presented in the *EOS Ground System Architecture Description Document.*

3.1 EOSDIS

3.1.1 EOSDIS Description

The EOSDIS serves as NASA's MTPE science data system for information management, data processing, archival, and distribution of NASA Earth science data. It provides computing and network facilities to support the EOS research activities, including data interpretation and modeling; EOS data processing, distribution, and archiving; and planning, scheduling, monitoring, and control of the spacecraft and instruments. The EOSDIS also provides access to current and upcoming non-EOS Earth science data sets through the Version 0 working prototype system; Version 0 is discussed in Section 3.1.4.3. Figure 3-1 depicts the EOSDIS components within the EGS as shaded.

3.1.2 EOSDIS Goals and Objectives

To support achievement of the MTPE Program's mission objectives, the EOSDIS will

a. Provide a unified and simplified means for obtaining and manipulating Earth science data.
b. Provide prompt access to all levels of data and documentation concerning the processing algorithms and validation of the data, and to data sets and documentation that result from research and analyses conducted using the data provided by EOS.

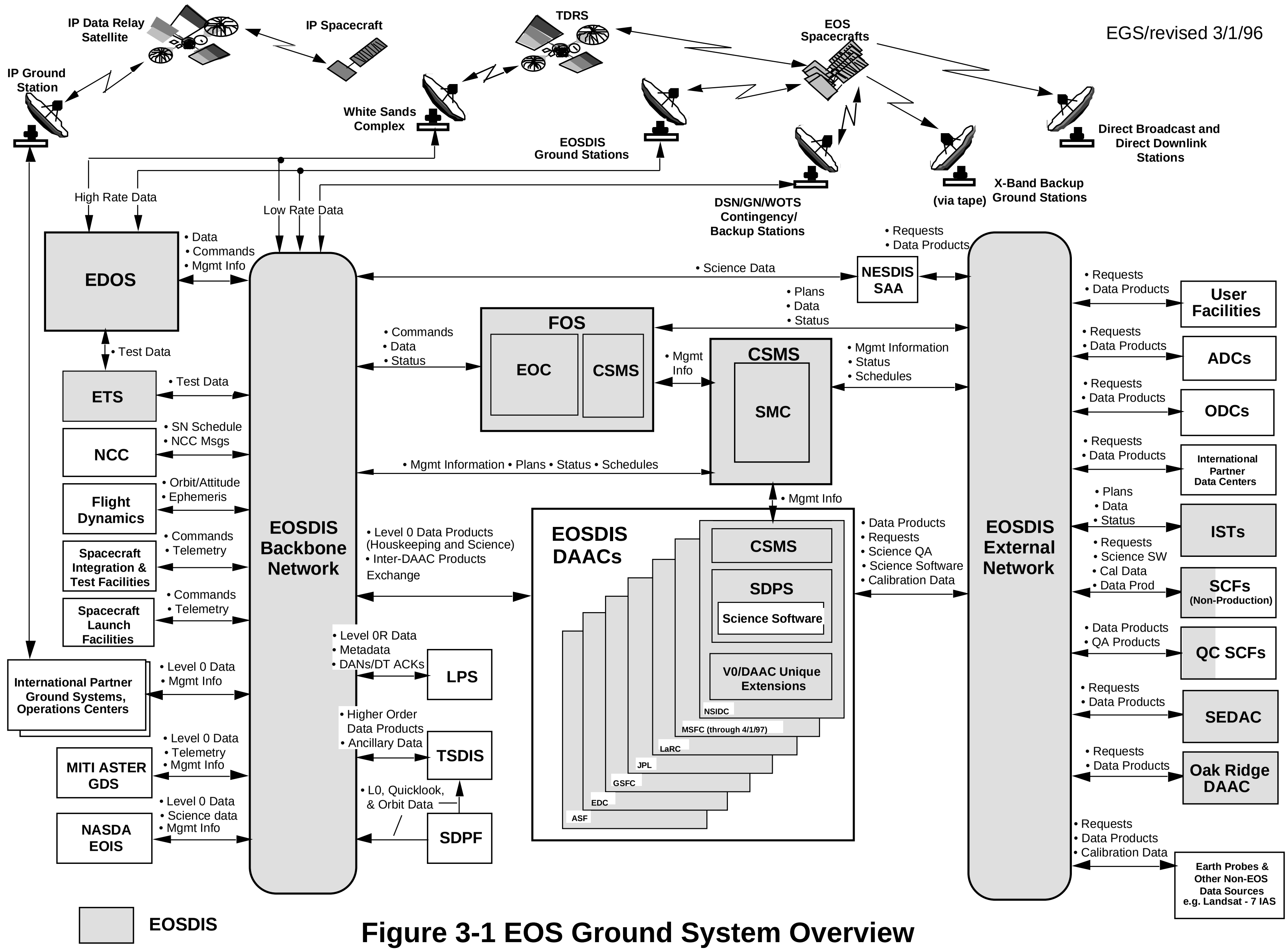

Figure 3-1 EOS Ground System Overview

c. Provide capabilities for a distributed community of Earth scientists to interact with data sources and mission operations from their own facilities.
d. Be responsive to user needs.
e. Facilitate evolution, growth and adaptation to new sources of data and new data system technologies.
f. Perform command and control of the EOS instruments and spacecraft.

3.1.3 Key EOSDIS Requirements

The EOSDIS is a comprehensive data and information system that must perform a wide variety of functions, supporting a diverse national and international user community. EOS data products will be used by a wide spectrum of scientists and the general public throughout the extended life of the program and in the decades to follow. This commitment to provide a long-term data base of usable scientific information to the various user communities distinguishes EOSDIS from current remote sensing data systems.

The key requirements to be met by EOSDIS are

a. Perform planning, scheduling, command, and control functions for all the EOS spacecraft and the instruments on-board such spacecraft,
b. Capture the data from all EOS spacecraft and process these data to create level 0 data products (i.e., raw data as measured by the instruments),
c. Support the generation of higher level (levels 1 - 4) standard products and special products,
d. Archive and manage all the standard and special products generated from the EOS instruments during the mission life, and distribute (or provide access to) requested subsets of the products to users either electronically or on appropriate media. In addition, archive and distribute data from other sources that are part of the MPTE,
e. Provide convenient, user friendly mechanisms for locating and accessing subsets of products of interest; facilitate collaborative science by providing tools and capabilities to provide users access from their own facilities,
f. Provide comprehensive user support to aid users with a wide variety of needs and applications in identifying, locating, and using the data for their applications,
g. Accommodate system changes as technology and user requirements evolve,
h. Provide an open architecture that facilitates the introduction of new technologies and system expansion to provide new services and capabilities, and
i. Transfer the control of data held by EOSDIS to long-term archival agencies that have a vested interest and responsibility for management and distribution of such data.

3.1.4 EOSDIS Elements

NASA is implementing EOSDIS using a distributed, open system architecture. This approach allows for the distribution of EOSDIS elements to various locations to take advantage of institutional capabilities and areas of science expertise. Although EOSDIS is physically distributed, it appears as a single logical entity to the users.

The EOSDIS performs five major functions:

a. Spacecraft command and control,
b. Data capture and level 0 processing,
c. Science data processing, archiving, and distribution,
d. Communications and systems management, and
e. Data communications.

The EOSDIS elements that perform these functions are the EOSDIS Core System (ECS), the EOSDIS Distributed Active Archive Centers (DAACs), EOSDIS Version 0, Science Computing Facilities (SCFs), the EOS Data and Operations System (EDOS), the EOSDIS Backbone Network (EBnet) and EOSDIS external network, and the EOSDIS ground stations. Figure 3.1.4-1 shows a high-level view of the EOSDIS reference architecture including these elements. This figure builds on the EOS mission general operations concept shown in Figure 2.6-1 by allocating the EGS functions to EOSDIS elements. There is an additional EOSDIS element; the EOSDIS Test System (ETS), not shown in the figure, which provides test data generation and simulation capabilities for the EGS elements during development, integration and test, and launch preparations.

3.1.4.1 EOSDIS Core System

The ECS provides the services and functionality to command and control the EOS spacecraft and instruments, process data from the EOS instruments, and manage and distribute EOS data products and other selected data sets. In addition to the EOS series of spacecraft and instruments, the ECS provides information management and data archive and distribution functions for other Earth science missions, including the Tropical Rainfall Measuring Mission (TRMM), Landsat 7, Pathfinder missions, instruments on spacecraft flown by international partners, and Earth Probe satellites.

The ECS consists of three segments defined to support three major operational areas: flight operations, science data processing, and communications and system management. These segments are briefly described in this section; the *ECS Operations Concept for the ECS Project* describes them in more detail.

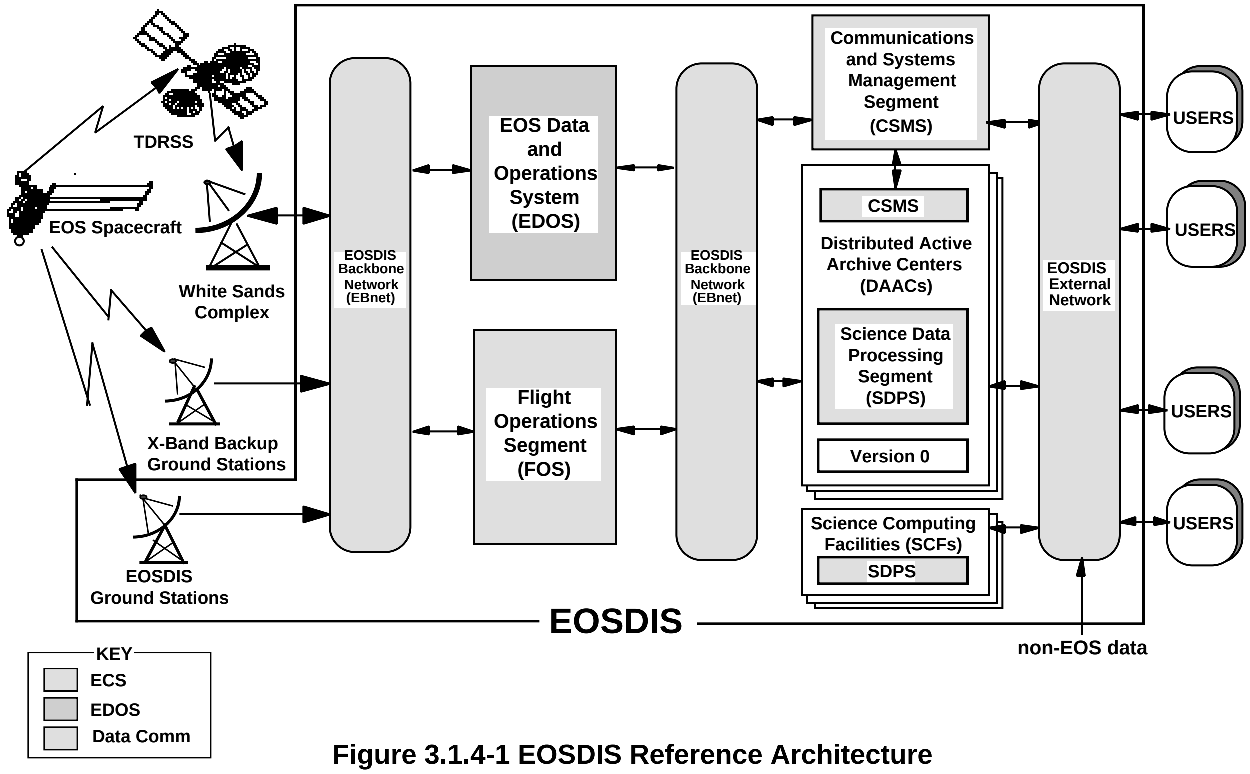

Figure 3.1.4-1 EOSDIS Reference Architecture

3.1.4.1.1 Flight Operations Segment

The Flight Operations Segment (FOS) manages and controls the EOS spacecraft and instruments. The FOS is responsible for mission planning, scheduling, control, monitoring, and analysis in support of mission operations for U.S. EOS spacecraft and instruments. It provides services to

a. Integrate schedules for spacecraft, instrument, and ground operations,
b. Manage the preplanned commands for the spacecraft and instruments,
c. Transmit command data, either real-time commands or command loads to EDOS for uplink to the spacecraft during each real-time contact,
d. Receive and process housekeeping data from EDOS,
e. Monitor overall mission performance and performance trends, maintain on-board software and spacecraft orbit, and manage the on-board systems,
f. Monitor and manage the configuration of the EOS Operations Center (EOC),
g. Manage the real-time interfaces with the Network Control Center (NCC) and EDOS, and with other ground stations, as applicable,
h. Maintain and update the project data base and FOS history log, and
i. Provide character-based and graphical display interfaces for FOS operators interacting with the other FOS services.

The FOS consists of two elements, the EOC and Instrument Support Terminals (ISTs). The EOC focuses on the command and control of the EOS flight segment and the interaction it has with the ECS ground operations. An IST connects a principal investigator (PI) or team leader (TL) at a remote facility to the EOC in support of instrument control and monitoring. ECS provided instrument support toolkits running on their remote terminals enable PIs and TLs to participate in planning, scheduling, commanding, and monitoring their instruments from remote sites.

3.1.4.1.2 Science Data Processing Segment

The Science Data Processing Segment (SDPS) provides for the generation and maintenance of EOS science data products for distribution to users. It provides the science community with the infrastructure to access EOS science data and with products resulting from research activities that utilize these data. The SDPS is a distributed system located at the DAACs and the SCFs. It provides services to

a. Receive, process, archive, and manage all data from EOS instruments and NASA flight missions, other selected remote sensing data, and their associated data products,
b. Receive, archive, and manage ancillary data required by EOSDIS algorithms,
c. Receive, archive, and manage correlative data,
d. Provide users access to all Earth science data held by the EOSDIS and to the data products resulting from research using these data,
e. Promote effective utilization of data for research in support of MTPE goals, and
f. Facilitate the development, experimental use, and community acceptance of new and improved algorithms.

3.1.4.1.3 Communications and System Management Segment

The Communications and System Management Segment (CSMS) provides for the interconnection of users and service providers, transfer of information between the ECS and many EOSDIS components, and status monitoring and coordination of EOSDIS components. It supports interfaces with the FOS and the SDPS to provide ECS operations, management, and maintenance personnel access to CSMS management services. These interfaces support a wide range of status reporting, operations coordination, and administrative and maintenance services. The CSMS provides services to

a. Generate high level ground event schedules,
b. Manage the configuration of all elements of the ECS and support configuration management of EOSDIS elements,
c. Monitor and evaluate site and element performance and performance trends,
d. Locate, identify, and isolate fault conditions, and identify corrective actions,
e. Manage security for all ECS elements and exchange security information across EOSDIS elements,
f. Perform security, data, and user audits; and maintain end-to-end data accountability, financial services, and resource utilization and cost information,
g. Establish and maintain user, facility, and system profiles, and
h. Generate a wide range of operational and administrative reports.

The system-level CSMS functions are located at the System Monitoring and Coordination Center (SMC). The SMC provides the capabilities necessary to manage ECS resources, at the ECS site level and for EOSDIS system-wide resources. The CSMS supports the FOS and the SDPS with physical network connectivity for their workstations, servers, and peripheral components. CSMS also provides local system management services at the DAACs and the EOC for use in managing the ECS provided capability, and exchanges status information with other EOSDIS elements to maintain a current system-wide view of EGS operational status.

3.1.4.2 Distributed Active Archive Centers

The DAACs provide facilities and operations for the production, archive, and distribution of EOS science data products. The DAACs are custodians of EOS mission data and other Earth science data and ensure these data are accessible to authorized users. DAACs receive level 0 data from EDOS, the Sensor Data Processing Facility (SDPF), and selected ground stations. DAACs also exchange production planning information with data centers that are part of MTPE but external to the EOS Program, and receive data from these data centers in the form of level 0, ancillary, or processed data sets and the associated metadata. The ECS supports the DAACs by providing SDPS components at their sites. SDPS provides the DAACs the operational interfaces required for management and control of algorithm integration and test, science product generation, data archiving and distribution, and user support services. DAACs provide data and information services, including comprehensive user support, to their users. These users include each DAACs specific discipline-oriented user community, the broader interdisciplinary global change community supported by all DAACs collectively, and NASA-sponsored EOS investigators. NASA-sponsored investigators develop science software for production use at the DAACs, and in some cases provide products generated at their own sites to the DAACs for archive and distribution to other users.

3.1.4.3 EOSDIS Version 0

The first version of EOSDIS, designated Version 0 (V0), is a working prototype which incorporates some operational elements. The development of V0 began in 1991 as a collaborative effort between the ESDIS Project, the DAACs, and the NOAA Satellite Active Archive, with the goal of improving the access to existing Earth science data held at the institutions that were designated DAACs. Several of these institutions had data systems that were developed independently, and were serving user communities in specific Earth science disciplines. These systems constituted the operating elements which were improved in their data holdings and levels of service to users during the development of V0, and incorporated in V0 in order to provide non-interrupted service to the science community. The data sets supported by the DAACs, levels of service provided for each dataset, and plans for the near future are documented in the *Science Data Plan*, which is updated yearly by NASA.

The working prototype in VO provides an Earth system science view across all DAACs, and permits searching and ordering their data holdings through a single session regardless of where the data are held. It interconnects existing Earth science data systems via electronic networks, interoperable catalogs, and common data distribution procedures to provide better access to existing and pre-EOS data. Due to the heterogeneity of the existing Earth science data systems at the DAACs, this is a good prototype for the logically distributed architecture intended for EOSDIS. In the development of V0, the key areas of emphasis were: developing collaborative relationships among the participating institutions, populating the databases and their inventories with datasets as prioritized by the user community, demonstrating distributed information management, benefiting from the wealth of experience gained in building these systems during the past decade, and applying the lessons learned to the subsequent versions of EOSDIS. V0 became operational in August 1994.

Concurrent with the development of V0, NOAA and NASA started a parallel effort to produce new data. This effort is called the Pathfinder data set development. The Pathfinder effort will improve access to particular data sets, and produce new products developed by community consensus algorithms. V0 provides access to the NOAA/NASA Pathfinder data sets, which will be archived and managed by the DAACs.

3.1.4.4 Science Computing Facilities

Science Computing Facilities (SCFs) provide the DAACs with science data processing software, quality assessment procedures, calibration parameters, and instrument data quality assessments, to support DAAC operations processing. The SCFs are computing facilities used by EOS investigators and located at science investigator sites. SCFs, which range from individual workstations to supercomputers, are used to develop and maintain science software and models for the generation of standard and special products; produce data sets; assess the quality of data, data products, and processing algorithms; and conduct scientific investigations with EOS and other Earth science data. The investigators at SCFs access instrument data at the DAACs and receive science data products. They provide high-order data products, instrument calibration data, product quality analysis results, science data processing software, and science research results to the DAACs. The interfaces and algorithm toolkits necessary to support these activities are provided by the ECS. Certain SCFs, collocated with investigators responsible for standard products, are designated Quality Control (QC) SCFs. QC SCFs perform scientific quality control of the data products.

3.1.4.5 EOS Data and Operations System

The EDOS provides capabilities for handling EOS spacecraft data compatible with the applicable Consultative Committee for Space Data Systems (CCSDS) recommendations. EDOS performs forward-link processing of command data, return-link processing of science and housekeeping data from the spacecraft and instruments, processes telemetry to generate level 0 products, and maintains a backup archive of level 0 products. These services are briefly described in this section; the *EDOS Operations Concept* describes them in more detail.

3.1.4.5.1 Return and Forward Link Processing

EDOS return and forward link processing services provide for the receipt, capture, processing, and transfer of all EOS digital data that conform to the applicable CCSDS communications services. Services include forward link real-time processing, return link real-time processing, data capture, rate buffering, and playback processing. All services include data quality assurance and accounting.

3.1.4.5.2 Production Data Handling

EDOS production data handling services are provided for mission data received from the EDOS return link service. Two services are provided, production data processing and expedited data processing.

Production data processing is the process by which packets from one or more TDRS service sessions (TSSs) are sorted by applications process identifier (APID), forward-ordered by sequence counter, and quality-checked. A production data set (PDS) is generated by deleting redundant and previously processed packets and adding quality and accounting summary information.

Expedited data processing is similar to production data processing, with the following exceptions. The content of the output expedited data set (EDS) is limited to either all packets received for a single APID during one TSS, or all packets in one TSS in which the expedite flag is set in the data packet secondary header. Redundant packets within an EDS are removed. However, since EDS processing focuses on a single TSS and does not take into account any data that arrived in a previous TSS, redundant packets between service sessions are not removed. Therefore, two EDSs could contain redundant data. The packets contained in an EDS are included in production data processing for the corresponding TSSs. The normal volume of expedited data processing is limited to a small percentage of all return link data received over a 24-hour period.

3.1.4.5.3 Data Archive

The EDOS data archive service provides a long-term storage capability as a backup to the DAAC archives for level 0 data. The production data sets generated by EDOS are recorded and stored for the life of EOS plus three years. Retrieved data sets, together with associated quality and accounting information, are delivered to the requesting DAAC as archive data sets. The data archive service can recover lost or damaged production data sets by requesting replacement data from the primary (DAAC) archive.

3.1.4.6 EOSDIS Backbone Network and EOSDIS External Network

The EBnet and EOSDIS external network provides wide-area communication circuits and facilities between and among various EGS elements, to support mission operations and to transport mission data between EGS elements. The networks are responsible for transporting spacecraft command and control data and science data nationwide on a continuous basis, 24 hours a day, 7 days a week

Real-time data includes mission-critical data related to the health and safety of on-orbit space systems as well as pre-launch testing and launch support. These data include spacecraft and instrument command and control data, telemetry from the spacecraft and instruments, and mission operations data such as schedules, orbit and attitude data, and status information.

Science information includes mission science data collected from the spacecraft instruments, and various levels of processed science data including expedited data sets, production data sets, and rate-buffered science data

In addition to providing the wide-area communications through common carrier circuits for internal EOSDIS communications, EBnet serves as the interface to other systems such as DAACs, users, and the NASA science internet (NSI). EBnet also includes Exchange Local Area Networks (LANs) which provide communications between the Wide Area Network and site-specific LANs.

EBnet and external network capabilities are described in more detail in *[document citations to be supplied]* .

3.1.4.7 EOSDIS Test System

The ETS provides an early source of CCSDS formatted data during EOSDIS development and a variety of simulation and test support functions to verify EOSDIS elements, interfaces, and capabilities throughout the system life cycle.

The ETS can simulate EOSDIS systems, other EGS elements, and EOS spacecraft. It provides high-rate simulation functions up to 150 megabits per second to mimic the Ku-band science data stream input to EDOS and the corresponding EDOS output products, and low-rate simulation functions to mimic the generation and processing of S-band telemetry and spacecraft commands. The ETS also simulates the operations management data in administrative messages required to test EOSDIS mission operations and system management functions.

ETS capabilities are described in more detail in the *EOSDIS Test System (ETS) Operations Concept*.

3.1.4.8 EOSDIS Ground Stations

The EOSDIS ground stations provide the primary space to ground communications services between the EOS spacecraft (except AM-1) and the EOSDIS. The EOSDIS ground stations comprise the Radio Frequency (RF) ground terminal, the EDOS ground station interface, and the EBnet telecommunication system. The RF ground terminal provides space to ground link communications channels for receipt of high-rate science data, receipt of spacecraft telemetry data and transmission of spacecraft commands for two EOS spacecraft simultaneously, including X-Band and S-Band capabilities. The EDOS ground station interface monitors and captures the high-rate science data and transfers captured data to the EDOS level 0 processing facility at GSFC. The EBnet telecommunication system consists of equipment to establish the connection to leased telecommunication lines.

3.2 Institutional Facilities

3.2.1 Institutional Facilities Description

As described in earlier sections, the EOSDIS interacts with a number of systems, facilities, networks, and organizations to accomplish the EOS mission. Institutional facilities are not dedicated to any one mission, but provide a wide range of services to many different missions simultaneously. This section describes the major data flows between EOSDIS and the external institutional facilities providing services to the EOS missions; these interfaces are represented in the high-level EGS architectural overview shown in Figure 3-1.

3.2.2 Institutional Facility Interfaces

Each interface is discussed by introducing the external institutional element and briefly describing the major data flows between the element and EOSDIS. Additional details describing the degree of services provided and types of data exchanged can be found in the appropriate facility documentation and corresponding interface control documents.

3.2.2.1 Flight Dynamics

Flight Dynamics provides navigational support, predicted orbit, and attitude information for EOS spacecraft. Flight Dynamics receives housekeeping telemetry parameters from the EOC, supports operational orbit determination, and provides orbit predictions and maneuver parameters to the EOC, along with attitude determination and attitude control evaluation of EOS spacecraft.

3.2.2.2 Nascom

Nascom provides certain communications services to EOSDIS independent of EBnet from prior arrangements or because of the special nature or attributes of the service. This includes, for example, the communications between the White Sands Complex and the Network Control Center to schedule and control the resources of the Space Network (SN).

3.2.2.3 Space Network

The SN provides the forward and return link communications between AM-1 and EDOS. The NCC provides schedules to the EOC for TDRS contacts for nominal operations. The NCC also provides schedules for other ground stations for EOS spacecraft contingency support.

3.2.2.4 Ground Network, Deep Space Network, Wallops Orbital Tracking Station

The GN, DSN, and WOTS provide low-rate S-Band contingency and/or emergency command and telemetry communications support for EOS spacecraft. These stations provide spacecraft and instrument housekeeping data to EDOS and the EOC, and receive command data from EDOS and EOC for uplink to EOS spacecraft.

3.2.2.5 X-Band Backup Ground Stations

Two ground stations, located at high latitudes, will provide backup high-rate X-Band communications for the AM-1 spacecraft playback science data in the event of a failure of the on-board TDRSS communications system.

3.3 Participating Programs

3.3.1 Participating Program Description

As described in earlier sections, the EOSDIS interacts with a number of systems, facilities, networks, and organizations to accomplish the EOS mission. Certain external programs participate in the MTPE/EOS program by exchanging data and/or services with the EOSDIS. This section describes the major data flows between EOSDIS and the program facilities participating in the EOS program; these interfaces are represented in the high-level EGS architectural overview shown in Figure 3-1.

3.3.2 Participating Program Interfaces

Each interface is discussed by introducing the external participating element and briefly describing the major data flows between the element and EOSDIS. Additional details describing services provided (if any) and types of data exchanged can be found in the appropriate participating element documentation and corresponding interface control documents.

3.3.2.1 EOS Spacecraft Ground Support

Several NASA and spacecraft manufacturer facilities external to EOSDIS provide spacecraft development and launch support. Spacecraft integration and test facilities exchange engineering data between the space system (spacecraft and instruments) and the EOSDIS. Launch support is provided by a spacecraft launch facility, such as the spacecraft and launch facility at Vandenberg Air Force Base for AM-1. The launch facility participates in pre-launch engineering tests, receives commands and data from EOSDIS for transmission to the spacecraft, and provides mission health and safety telemetry to EOSDIS during launch and initial ascent.

3.3.2.2 International Partner Facilities

International partners such as the European Space Agency, Japanese organizations, and the Canadian Space Agency provide spacecraft and instrument payloads, data acquisition, processing, archiving, and distribution capabilities to EOSDIS. The IP instrument control centers (ICCs) exchange data with the EOC to support planning and scheduling, commanding, and instrument operations for IP instruments. IP ground systems provide data products to DAACs. The ASTER ground data system receives ASTER instrument data from EDOS.

3.3.2.3 Affiliated Data Centers and Other Data Centers

Affiliated data centers (ADCs) and other data centers (ODCs) coordinate data availability with the DAACs and provide selected science data products to the DAACs. EOSDIS elements access these data to satisfy user queries and as correlative data for standard products generated by EOSDIS. A NOAA facility receives CERES instrument data directly from EDOS.

The SDPF at GSFC processes TRMM science data to level 0 and provides selected instrument data to DAACs and other instrument data to the TRMM Science Data Information System (TSDIS) for higher-order processing. The TSDIS provides TRMM data products and metadata to DAACs for archive, distribution, and further processing.

The Landsat 7 Processing System processes Landsat 7 instrument data to level 0R and provides data products and metadata to a DAAC for archive and distribution.

3.3.2.4 User Facilities

Program-sponsored investigators participate in specifying the data to be collected, operating the instruments, and analyzing the science data and data products. Investigators generally interact with EOSDIS through facilities such as SCFs, ISTs, and DAACs.

Public users access the EOSDIS via external networks. These users request data and information and receive data products from the EOSDIS. Public users may also acquire tools from EOSDIS to support search, data order, and data manipulation functions.

3.3.2.5 NASA Science Internet

The NASA Science Internet (NSI) is an open communications network that serves the needs of NASA's diverse science and research community worldwide. The NSI provides connectivity between the AM-1 instrument support terminals (ISTs) and the EOC, and between DAACs and instrument teams QC SCFs. It provides data communications services between EOSDIS and user facilities, ADCs and ODCs, IP data centers, other data sources, and other projects, and provides DAAC connectivity to the internet for all users.

3.4 EGS Implementation Approach and Evolution

The EGS is being developed in an evolutionary manner with extensive input from, and testing by, the science community. This approach is a step-by-step process that allows the graceful transition of the system from the existing diverse Earth science data and information systems to the EGS configuration. The system will be operational before the launch of the first EOS spacecraft and will thereafter continue to evolve in response to scientific research needs.

As a major component of the EGS, the EOSDIS is designed to accommodate technology insertion and functional expansion. During implementation of each version the "build to" specification includes provisions for accommodating the growth needs of future releases. The development approach is structured to ensure that the design also incorporates lessons learned from user experience with existing NASA data sets, as well as the results of prototyping efforts for the various EOSDIS elements. Prototyping results and user feedback will continue to be incorporated into new versions of EOSDIS following successful demonstration and acceptance by the program.

Implementation of new EOSDIS versions is planned to have minimal disruption to current EGS operations. The ESDIS Project level 2 requirements include overall system architecture requirements that define an architectural environment and specify incorporation of technologies that facilitate this process. EOSDIS will be built incrementally in multiple versions. The evolution of EOSDIS begins with Version 0 (V0) and will continue with subsequent versions. Each version will provide mission-specific operational capabilities; each subsequent version will provide an expanded increment of those capabilities to support future missions.

The first version of EOSDIS, designated Version 0 (V0), is a working prototype incorporating some operational elements. The development of V0 was started in January, 1991 with the goal of improving the access to existing Earth science data held at institutions that were designated DAACs. It interconnects existing Earth science data systems via electronic networks, interoperable catalogs, and common data distribution procedures to provide better access to existing and pre-EOS data. Beginning with existing, heterogeneous Earth science data systems, V0 will evolve toward the full EOSDIS by taking maximum advantage of existing experience and ensuring that no disruption in current user services occurs. Through the interconnection of the existing systems, V0 serves as a functional prototype of selected key EOSDIS services. As a prototype, it does not have all the capabilities, fault tolerance, or reliability of the later versions; however, EOSDIS V0 supports use by the scientific community in day-to-day research activities. Such use tests existing services to determine the additional or alternative capabilities required of the full EOSDIS. V0 became operational in August, 1994.

EOSDIS Version 1 (V1) is planned for release in January, 1997. It will provide support for the TRMM mission that will include: product generation from the EOS instruments (CERES and LIS) and archival and distribution of data products resulting from TRMM instruments. V1 also will support the early testing of EOS AM-1 spacecraft command and control, and the testing of interfaces between the FOS, EDOS, EBnet, and the NASA institutional capabilities supporting EOSDIS. V1 will reflect user feedback from V0 to enhance operations in all areas, with special emphasis on user sensitive areas. For providing users with uninterrupted access to data and information, V0 and V1 will operate in parallel until the data from V0 are migrated into the V1 system and the V0 hardware components become obsolete. During this period, the two systems will interoperate. V1 will address technology and data volume issues and provide increased capacity and functionality over V0.

EOSDIS Version 2 (V2) is planned for release in October, 1997. V2 will enhance V1 functionality and expand capability to the level needed to support AM-1 mission operations. V2 will also support Landsat 7 data archiving and distribution.

Subsequent versions of EOSDIS will supplement capacity and services as required by EOS spacecraft launches. EOSDIS capabilities will evolve based on continuing evaluation by the research community, and technology will be enhanced as the need arises.

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Section 4. EGS Operations

The EGS operations goals are to support EOS Program science objectives by collecting Earth science data; converting these data into useful products and making the data and products accessible to a broad user community; and coordinating the activities of widely distributed facilities, systems, networks, and organizations into a single efficient and effective operations entity. To accomplish these goals, EGS operations are divided into three major categories comprising the following functions; mission operations, science data operations, and EGS monitoring and coordination.

EGS mission operations includes the functions required for EOS space systems (instruments and spacecraft) planning and scheduling; command management, spacecraft monitoring, and orbit maintenance; and data capture and level 0 processing of EOS science and engineering data.

EGS science data operations includes the functions required to ingest and process the data and generate data products; establish and maintain EOSDIS data archives; assess the quality of the science data and user products; and provide a wide range of user services including product ordering and distribution.

EGS monitoring and coordination includes functions to perform the system-wide oversight and operations coordination necessary to ensure that EGS operations are consistent with EOS Program goals and objectives.

The functions that make up mission operations, science data operations, and EGS monitoring and coordination are briefly summarized in Table 4-1. This section presents selected scenarios to illustrate at a summary level how elements of the “as built” EGS architecture work together to accomplish the required EGS operations activities and processes. Figure 4-1 is an operations scenario roadmap intended to illustrates the interrelationships among the EGS operations scenarios presented in this section. The scenarios discussed correspond to the functions identified in Table 4-1.

This section concludes with summary level descriptions of operations support functions not addressed in the scenario descriptions, but required to maintain the systems that perform EGS operations, and to support the evolution of the mission operations, science data operations, and EGS monitoring and coordination capabilities. The operations support functions discussed are: sustaining engineering; system maintenance; EOSDIS configuration management; data management; training and certification; and operations readinesss verification.

4.1 Mission Operations

EGS mission operations includes the operations capabilities to perform planning and scheduling; command management and spacecraft monitoring; and data capture and

Table 4-1 Summary of EGS Operations Functions

Function	Operations Scenario	Description
	Planning and Scheduling	• Generate long-term plans, baseline activity profiles, and detailed activity schedules for EOS instruments and spacecraft
	Command Management and	• Perform command and control of EOS

Mission Operations	Spacecraft Monitoring	spacecraft • Monitor spacecraft telemetry to insure spacecraft health and safety • Determine and maintain the spacecraft orbit and on-board timing
	Data Capture and Level 0 Processing	• Capture and record EOS spacecraft data • Process and deliver real-time housekeeping data in real time • Generate and deliver level 0 data sets • Establish backup level 0 data archive
Science Data Operations	Data Ingest, Archiving, and Archive Maintenance	• Ingest and archive data from selected sources • Monitor and maintain the integrity of the data in the archive
	Data Processing, Ordering, Quality Assessment, and Distribution	• Generate and archive standard data products from all EOS level 0 data • Accept user orders for data products • Perform science data quality assessment • Generate and distribute products to users
EGS Monitoring and Coordination	Local EGS Management and Coordination, and EGS System-level Monitoring and Coordination	• Provides local domain specific management and operations, and inter-domain coordination • Provides EGS-wide operations status and performance reports • Provides centralized billing and accounting • Maintains current ESDIS policies and procedures • Coordinates EGS-wide problem analysis and resolution as necessary

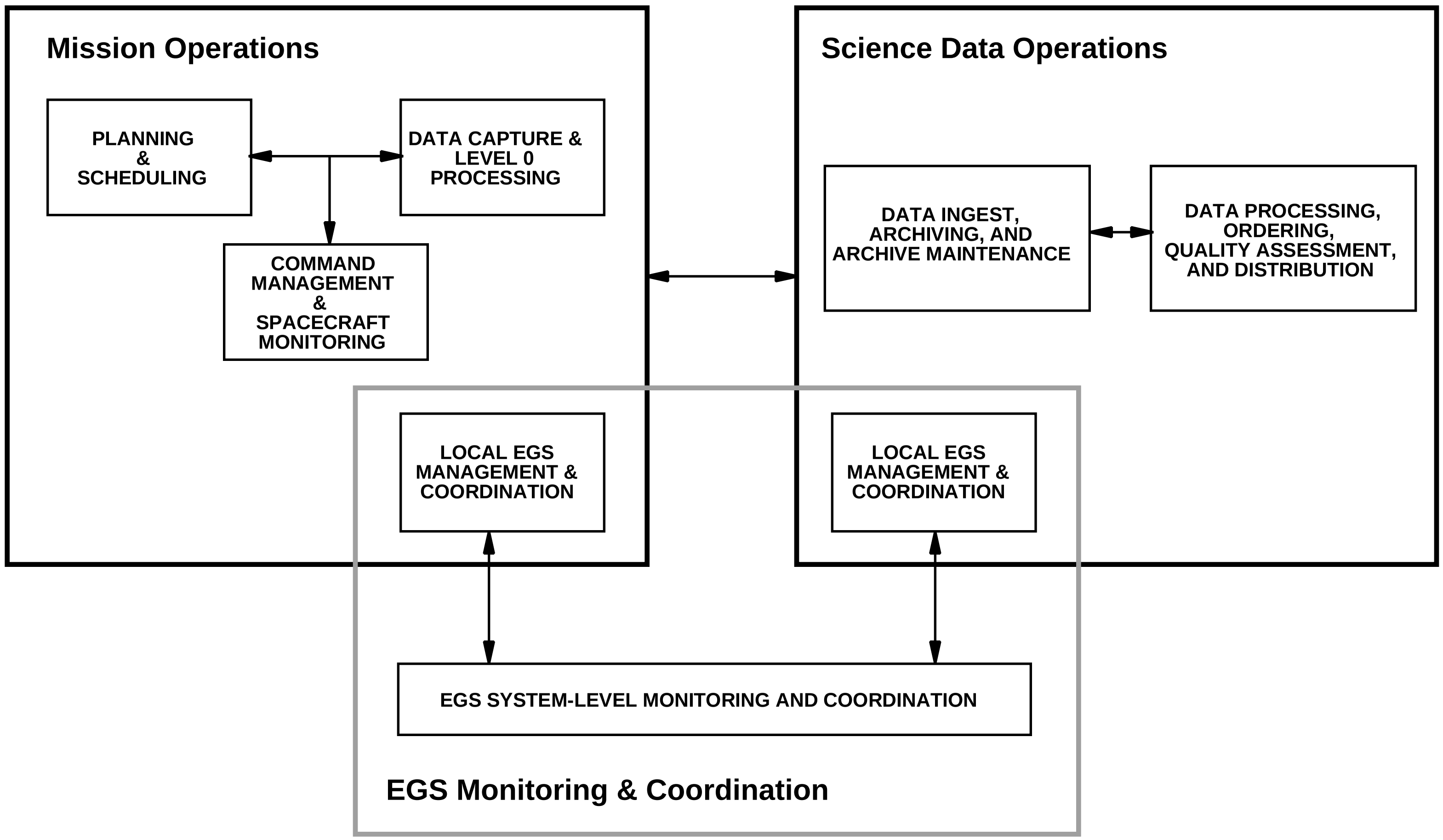

Figure 4-1 EGS Operations Scenario Roadmap

level 0 processing for EOS space systems (spacecraft and instruments). These functions are described at a summary level in this section.

4.1.1Planning and Scheduling

The planning and scheduling function produces a mission schedule that integrates the activities of the flight segment instruments and spacecraft subsystems. The science community, principal investigators (PIs), instrument operations teams (IOTs) and instrument team leaders (TLs), and international partners (IPs) have direct input and exert a major influence over the planning and scheduling of EOS instruments. Figure 4.1.1-1 identifies the EGS elements, participants, major interfaces, and operational processes involved in the performance of this function. Summary-level descriptions of these processes are provided in this section.

4.1.1.1 Long-term Planning

The long-term planning process provides the mission planning for approximately a five-year period and culminates in the development of long term plans for science, instrument, spacecraft operations, and mission activities.

The Project Scientist, the Investigators Working Group (IWG), and the science planning groups work in concert to prepare a long-term science plan (LTSP) with a planning horizon of approximately five years. The IWG updates this plan as required throughout the mission life; however, updates are expected to occur infrequently, not more than every 6 months. The LTSP establishes science priorities and objectives for each EOS mission flight. The plan may define periods of coordinated activities with other EOS spacecraft, with other Earth science missions, and with selected ground campaigns.

The LTSP is made available to PIs, TLs, IOTs, and the ASTER GDS for planning their instrument operations. The science community may also use the plan for preparing requests for data acquisition for observations by complex instruments, for coordinating correlative measurements, and for planning future science campaigns.

Using the LTSP, non-complex instrument profiles and the complex instrument profile from the ASTER GDS, and according to ESDIS Project programmatic priorities and guidelines, the PIs, TLs, and IOTs develop a long-term instrument plan (LTIP) that defines periods of instrument activity; periods in which spacecraft maintenance activity should be avoided, if possible; and periods of coordinated activity or special calibration activity when required. The contents of the LTIP are expected to be straightforward for non-complex instruments. In contrast, the LTIP has substantially more depth for complex instruments, describing the guidelines and priorities for scheduling data acquisition, targets of opportunity (TOOs), and calibration and maintenance activities. The LTIP also provides more detailed information, including periods of coordinated activities, specific targets and coverage requirements, science objectives for the upcoming period, and calibrations required before and after specific science observations.

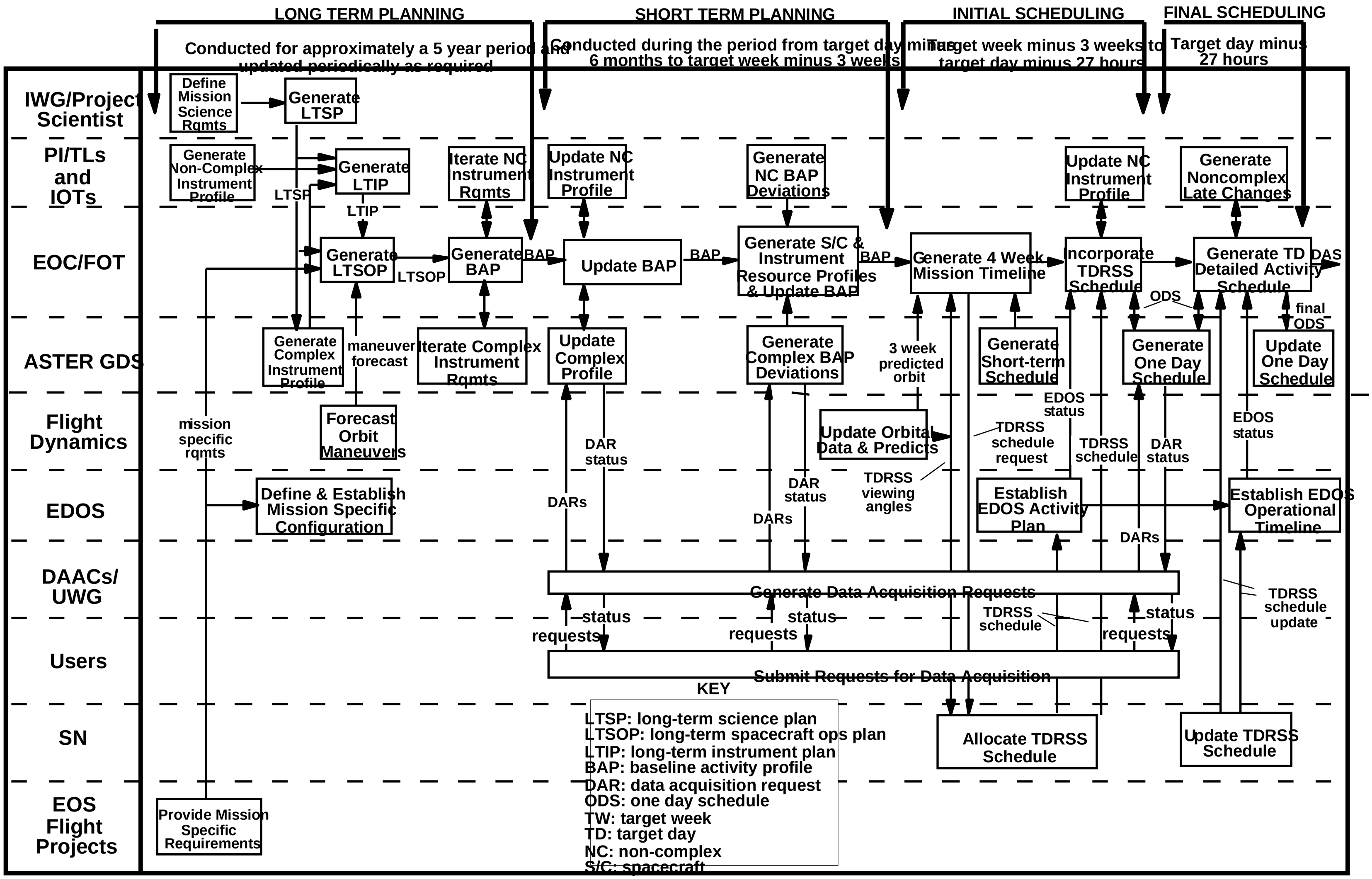

Figure 4.1.1-1 Planning and Scheduling Scenario

A long-term spacecraft operations plan (LTSOP) is developed by the flight operations team (FOT) for each spacecraft, using mission specific information provided by the flight projects, and the LTIP. Each LTSOP outlines expected spacecraft subsystem operations and maintenance, along with forecast orbit maneuvers from Flight Dynamics (FD). Spacecraft sustaining engineering and subsystem maintenance activities, subsystem calibrations, and spacecraft orbit adjustments are planned around science operations to the maximum extent possible; since these activities occur infrequently, the LTSOP is expected to be relatively straightforward. Each LTSOP is consistent with the associated LTIP and with mission specific information provided by the flight project.

Based on the LTSOP, and in conjunction with the PIs, TLs, IOTs, and IPs to identify any changes in the spacecraft operational performance, as well as upcoming spacecraft sustaining engineering and maintenance activities that may affect science operations, the FOT generates a Baseline Activity Profile (BAP). The BAP represents an integrated, operationally compatible spacecraft, instrument, EOSDIS, and institutional service plan that supports the short-term planning and scheduling processes.

4.1.1.2 Short-term Planning

Short-term planning may be required to perform needed adjustments to the BAP and to portions of the long-term plans. Typical updates are occasioned by the need to observe long-term impacts of recent TOO observations; the need to support newly created science campaigns; spacecraft, SN, or ground system resource limitations; or the submission of new data acquisition requests by users to acquire data of interest.

Non-complex instruments rarely deviate from their instrument activity profiles (IAPs); therefore, their scheduling process is often complete at this stage. However, the more complex an instrument, the more frequently deviations are expected to occur. In addition, complex instruments have generic IAPs because their scheduled activities are expected to vary significantly due to changing user acquisition requirements. The scheduling of deviations to IAPs depends upon available resources. The FOT assesses all instrument deviations from their original IAPs against available spacecraft resources in order to generate an updated BAP.

In the case of ASTER, users and investigators may want additional data and will be able to influence the EOS instrument data collection through the submission of requests for data acquisition. These users and investigators will access the EOSDIS to collect information concerning the potential for acquiring data of interest, analyze the information, and develop the request for data acquisition. Submission of the requests will be via the DAAC ECS client which will generate a data acquisition request (DAR) and forward it to the ASTER GDS instrument control center (ICC) for inclusion in the instrument activity profile. The ICC will review the DAR and issue an acceptance or rejection notice to the user or investigator via the DAAC. If accepted, the ICC will incorporate accepted DAR(s) into the IAP for the instrument so that the BAP can be updated accordingly. The DAACs also provide status information on DARs to users and investigators. Requests for data acquisition may occur at any time during the planning and scheduling process. The short-term planning process culminates in an updated BAP for instrument and spacecraft resource profiles to initiate the scheduling process three weeks prior to the target week.

4.1.1.3 Scheduling

Scheduling is carried out in two phases, initial scheduling and final scheduling.

Initial scheduling begins three weeks before the target week to resolve conflicts among requests for instrument observation time and generate a 4 week mission timeline. Conflicts will generally involve spacecraft resources related to instrument scheduling, late requests conflicting with existing scheduled activities, SN resources (AM-1 only), or contention between EOS spacecraft for X-band ground station contact periods.

Initial scheduling provides the FOT with early scheduling data to perform data management by assessing the required SN resources on the basis of the space system's accumulation of data for downlink. Before each spacecraft launch, spacecraft resources will be allocated to each instrument. It is therefore anticipated that little or no resource contention will occur among the instruments. For complex instruments however, late change DARs or TOOs could conflict with existing scheduled activities. Should conflicts arise, the FOT will initiate resolution steps with the ICC(s) and/or instrument support terminals (ISTs) representing the instruments in conflict. The final authority in conflict resolution will rest with the Project Scientist or designee for science conflicts and with the ESDIS Project Manager or designee for programmatic conflicts. The FOT will also consult with the mission operations manager (MOM) in resolving conflicts relative to the spacecraft and institutional resources.

Initial scheduling begins three weeks before the target week with the generation of a 4 week mission timeline by the FOT, resulting in a schedule request to the SN NCC for TDRSS services at approximately the target week minus two weeks. During the early part of the initial scheduling period, FD processes TONS real-time telemetry and generates three-week predicted orbits for the AM-1 spacecraft. The data are provided to the EOC for use in scheduling TDRSS coverage. In addition, FD also generates AM-1/TDRSS antenna viewing angles and times to support the EOC and the NCC in scheduling TDRSS coverage. The scheduling of EOS X-band ground stations will occur during this same time frame. The method for securing EOS X-band ground station contacts is to be determined. For either TDRSS or X-band contacts, scheduling within the multi-mission era attempts to resolve any conflicts among EOS spacecraft for the same service.

The ASTER GDS is responsible for providing the EOC with the short-term operating schedule and data rate profile for the target week, and an initial one day schedule (ODS) for the target day. An IST will provide the EOC/FOT with any schedule deviations for non-complex instruments. User and investigator acquisition requirements will be input via the DAAC and the ASTER GDS during this period. The EOC/FOT will factor in the spacecraft subsystem data rate profile to estimate the spacecraft data storage utilization and determine the SN resources required to dump the data. NCC processing of the EOC TDRSS schedule request results in an active TDRSS schedule at approximately target week minus one week.

EGS elements can either query the EOC flight segment operations schedule data bases or contact the FOT to acquire the schedules as required to support their activities.

Final scheduling begins 27 hours before the target day with the generation of a target day detailed activity schedule (DAS) by the EOC/FOT. The ISTs provide any final non-complex instrument updates. The final target day schedule is updated as necessary to be compatible with active EOS ground station schedules and/or negotiated SN schedules. Late change DARs or TOOs can be input to the ASTER GDS as late as twelve to fourteen hours before the observation time and will be incorporated into the final schedule using the negotiated space-to-ground schedule. The ASTER GDS creates the final ODS and transfers it to the EOC/FOT no later than seven hours before the operations day. Using these final inputs, the FOT generates the DAS for the target day to support spacecraft command generation. Late change DARs or TOOs incorporated into the final schedule may result in the deletion of other planned activities. Attempts are made to resolve conflicts using any flexibility in the scheduling process. The final authority in conflict resolution will rest with the

Project Scientist or designee for science conflicts and with the ESDIS Project Manager or designee for programmatic conflicts. The FOT will consult with the mission operations manager (MOM) in resolving conflicts relative to the spacecraft and institutional resources.

EGS elements can either query the EOC scheduling databases or contact the FOT to acquire summary target day activity schedules needed to support their activities.

4.1.2Command Management and Spacecraft Monitoring

The command management and spacecraft monitoring function performs processes to command the AM-1 spacecraft and instruments, monitor spacecraft and instrument performance by analysis of the spacecraft housekeeping data, and control the orbit of the spacecraft through orbit determination, orbit maintenance, and onboard time maintenance activities. Figure 4.1.2-1 identifies the EGS elements, participants, major interfaces, and operational processes involved in the performance of this function. Summary-level descriptions of these processes are provided in this section.

4.1.2.1 Command Management

Command management is performed by the FOT at the EOC, and on board the spacecraft. Commands for the spacecraft are generated at the EOC either in real time for immediate uplink and execution or as stored commands uplinked to the

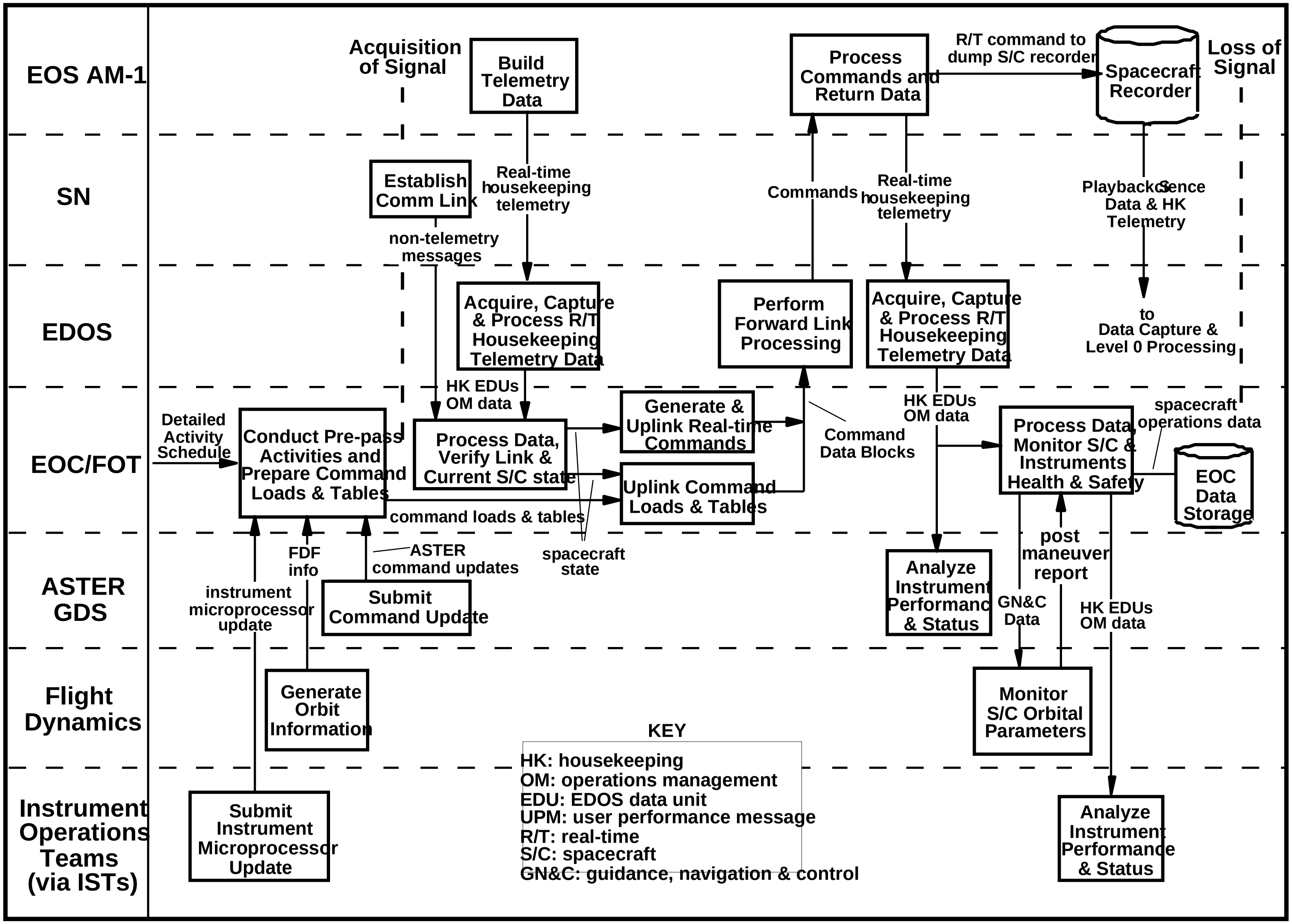

Figure 4.1.2-1 Command Management and Spacecraft Monitoring Scenario

spacecraft for execution at specified future times. Real-time commands are sent at any time during a Tracking and Data Relay Satellite (TDRS) contact, nominally to dump the onboard recorder or to react to a contingency situation. Stored command loads are nominally generated once per day for a 32-hour period and uplinked to the spacecraft 6 to 8 hours prior to the target day. The stored command period extends into the following day to ensure that the spacecraft and instruments have valid scheduled commands if the next day's command upload cannot be executed. To further insure the safety of the space system, the final commands in each stored command load configure the spacecraft and instruments into a project-defined safe condition.

The FOT in the EOC conducts their pre-pass activities which includes building a spacecraft command load and associated ground script based on the DAS, instrument command loads from the ASTER GDS and the ISTs, and orbit information through tools supplied by FD. The EOC/FOT validates the command load by performing a constraint check and critical commands check and prepares the command load. The FD orbit information is placed in tables for upload. At acquisition of signal (AOS) of the target pass, the SN acquires the downlink signal and transfers real-time housekeeping data in the form of channel access data units (CADUs) to EDOS and non-telemetry messages to the EOC. EDOS receives, captures, and processes the CADUs, extracting the housekeeping packets and producing EDOS data units (EDUs) that contain the housekeeping telemetry packet and operations management (OM) data. EDOS generates summary quality and accounting status data and transfers the packet EDUs and status data to the EOC in real time.

Processing these data, the EOC first verifies the link, begins monitoring the spacecraft and instruments, and checks the spacecraft state. The EOC ensures that the onboard command counters have incremented properly and that the downlink parameters in the housekeeping data are consistent with expectations based on the activities in the command load executing since the last spacecraft contact. If the state check is successful, real-time commands can be sent for immediate execution. Stored commands and tables also may be uploaded.

EDOS receives real-time commands and/or stored command tables as command data blocks, constructs the forward bit stream, and transmits the commands to the spacecraft through the SN. The spacecraft examines all commands received and indicates acceptance or rejection by the use of command link control words (CLCWs) inserted into the real-time housekeeping telemetry. CLCWs are stored in onboard memory and also transmitted to the ground as part of the real-time housekeeping telemetry data stream. Using CLCW data from the spacecraft which are received at the EOC via EDOS (as part of the spacecraft monitoring process), the EOC/FOT confirms real-time command receipt and execution and successful stored command loading. If either is unsuccessful, the FOT takes appropriate action.

4.1.2.2 Spacecraft Monitoring

During each TDRS contact space system real-time housekeeping data are continuously received and processed by EDOS in real time and immediately sent to the EOC and the ASTER GDS. The EOC/FOT, the ASTER GDS, and the IOTs monitor and analyze the spacecraft and instrument housekeeping data continuously during a contact, to verify the health and safety of the spacecraft and instruments. By continuous examination of the spacecraft housekeeping data, the FOT can react immediately to any non-nominal situation. Housekeeping data are recorded on board the spacecraft along with the science data throughout the complete spacecraft orbit. These data are dumped to the ground, processed by EDOS, and sent to the EOC to provide a complete record of the housekeeping data for the entire orbit for later analysis and as a historical record.

EDOS acquires, captures, and processes the real-time housekeeping telemetry from the spacecraft, extracts the CLCWs from the CADUs, and forwards the CLCW EDUs to the EOC. Using the housekeeping data and the CLCW EDUs, the EOC confirms both real-time command receipt and execution, and successful stored command loading. If the load is unsuccessful, the CLCWs provide the FOT with the knowledge to upload the stored commands a second time or investigate the cause of the rejection. The EOC extracts guidance, navigation and control (GN&C) data and provides it to FD. The EOC and ICCs continue to monitor the spacecraft and instrument housekeeping parameters until loss of signal (LOS). The EOC provides selected spacecraft data to the IOTs.

Housekeeping data are stored in spacecraft memory twice, as part of the science data storage and in a separate housekeeping storage; either may be used for normal housekeeping monitoring. Before LOS, science and housekeeping data accumulated over the previous orbit are dumped via a real-time command sequence. EDOS acquires and captures the spacecraft memory dump and stores the processed housekeeping EDUs. Within five minutes after LOS, EDOS rate-buffers the playback housekeeping EDUs to the EOC. The EOC adds the playback EDUs to the history log to provide a complete record of housekeeping data for the entire orbit for later analysis by the EOC, the ASTER ICC, and the IOTs.

4.1.2.3 Orbit Determination and Maintenance

AM-1 orbit determination is performed on board in real time by the TDRS Onboard Navigation System (TONS) with ground-generated ephemeris providing a backup capability. TDRS position vectors and backup ground computational support are provided by FD for daily uplink to TONS. TONS calculates spacecraft position in real time, and also includes TONS spacecraft ephemeris in the housekeeping data. EDOS captures both the real-time telemetry data and the playback data, extracts the housekeeping data, and sends it to the EOC. The EOC provides TONS spacecraft ephemeris to FD to monitor changes in spacecraft orbital position and verify TONS performance.

The EOC performs on board time maintenance by monitoring the spacecraft clock offset from the universal time received from the U.S. Naval Observatory, preparing and uplinking spacecraft clock update commands whenever the clock approaches the predetermined error limit, and verifying that the spacecraft clock was correctly updated.

Orbit adjust maneuvers are performed as needed to maintain the AM-1 spacecraft orbit within the specified parameters. FD monitors the ephemeris, analyzes
the orbit, and as necessary, prepares an orbit adjust maneuver plan for the EOC to execute. Based on the FD plan, the FOT prepares the maneuver command sequence, uplinks the command sequence to the spacecraft, and executes an orbit adjust maneuver. The results of the orbit adjust process are monitored by the FOT and FD in order to make any required adjustments necessary to achieve the desired orbit correction. FD generates a post-maneuver report and sends it to the EOC/FOT

4.1.3Data Capture and Level 0 Processing

The data capture and level 0 processing function receives and captures spacecraft data; processes the data to create level 0 expedited data sets and production data sets; distributes level 0 data; and stores all level 0 data long-term in a backup archive. Figure 4.1.3-1 identifies the EGS elements, participants, major interfaces, and operational processes involved in the performance of this function. For clarity, certain processes from the previous command management and spacecraft monitoring scenario are repeated (shaded on the figure). Summary-level descriptions of these processes are provided in this section.

4.1.3.1 Data Capture

During a TDRS contact EDOS acquires and captures the high rate Ku-band data stream, which contains both science and housekeeping playback data, from the SN return link. EDOS subsequently processes the physical channel data, generates operations management (OM) status data, and separates the playback science and housekeeping data into virtual channel data units and packets. Based on the intended destination, these data are sent as EDUs to EDOS level 0 processing functions or distributed directly as EDUs to other facilities. Throughout the TDRS service session (TSS), EDOS continuously monitors the data capture and initial processing and reports operations management status to the EOC. All CERES instrument data in the form of EDUs are sent directly to NOAA.

4.1.3.2 Level 0 Processing

Level 0 processing begins at the conclusion of a TSS. EDOS initiates level 0 processing based on data priority. Data identified for expedited delivery are processed first and delivered as expedited data sets (EDSs). Production data sets (PDSs) are generated for delivery to science processing facilities.

The SN notifies the EOC of loss of signal (LOS) indicating termination of contact. The EOC performs post-event operations to assemble a complete record of housekeeping data for later analysis. EDOS independently detects LOS and begins post-event operations, including generating a summary OM data status message for the EOC; initiating the rate-buffered transfer of CERES EDUs to a NOAA facility; and transmitting rate-buffered housekeeping EDUs containing a full orbit’s data and possibly redundant data packets to the EOC and ASTER GDS.

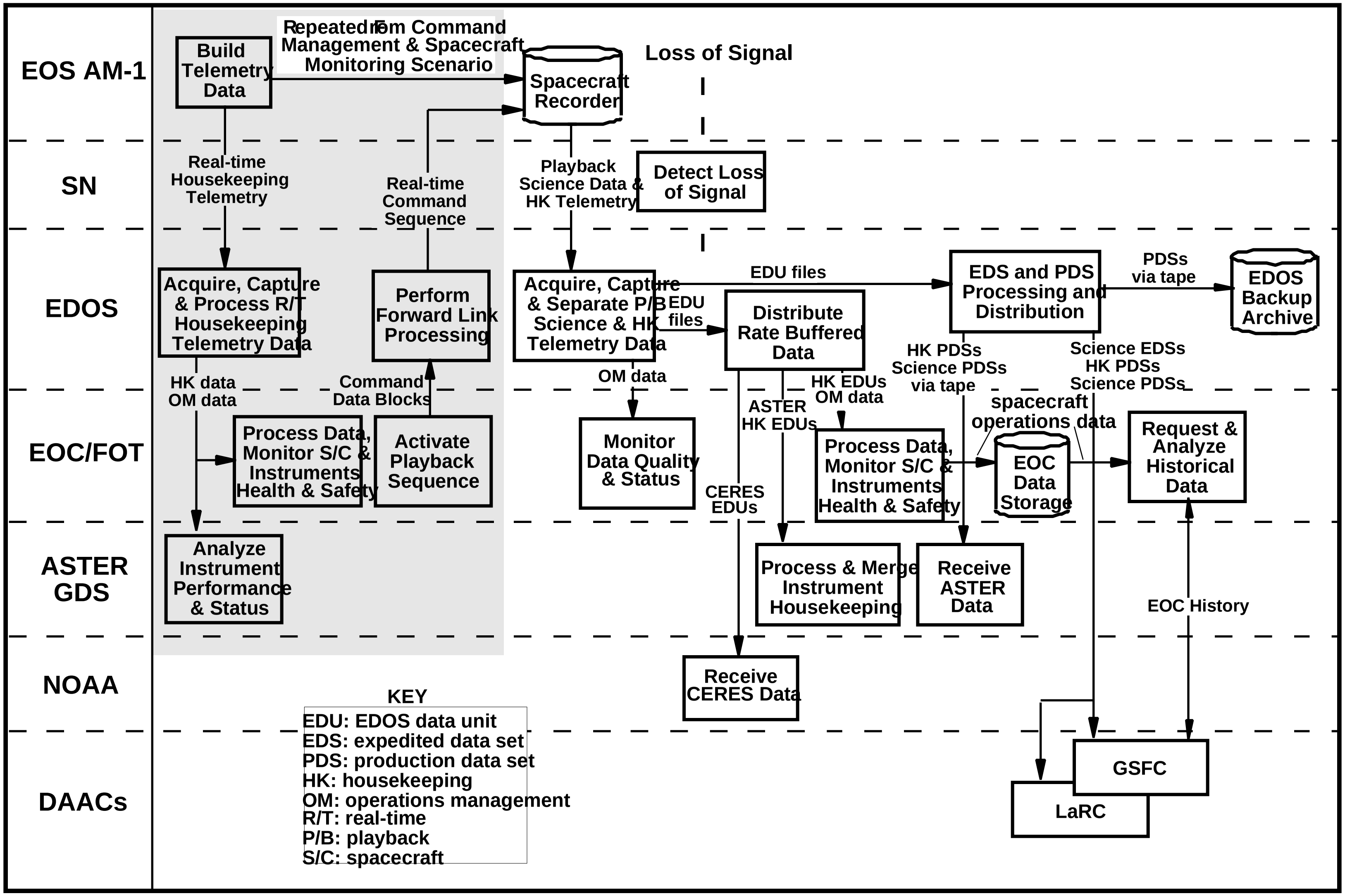

Figure 4.1.3-1 Data Capture and Level 0 Processing Scenario

EDSs are processed ahead of the PDSs. The content of the output EDS is limited to either all packets received for a single APID during one TSS, or all packets in one TSS in which the expedite flag is set in the data packet secondary header. Redundant packets within an EDS are removed. However, since EDS processing focuses on a single TSS and does not take into account any data that arrived in a previous TSS, redundant packets between service sessions are not removed. Therefore, two EDSs could contain redundant data. The packets contained in an EDS are included in production data processing for the corresponding TSSs. The normal volume of expedited data processing is limited to a small percentage of all return link data received over a 24-hour period. EDSs consisting of packets received during one TSS are distributed to the DAACs.

Level 0 processing is performed for all data, including the data previously processed for expedited delivery, to remove communication artifacts such as headers; sort data by application identifier; forward time order the data; remove duplicate data; and perform data quality checks. Level 0 production data sets (PDSs), with quality and accounting data appended, are constructed and delivered either electronically or on physical media to the appropriate destination. All level 0 PDSs are also recorded on physical media and sent to the EDOS backup archive. The DAACs receive science EDSs and science and housekeeping PDSs for further processing. ASTER data are sent directly to the ASTER GDS on physical media.

The GSFC DAAC maintains housekeeping PDSs to enable the EOC to access a full record of spacecraft and instrument housekeeping data for future analysis. This record provides a complete, non-redundant data set that replaces the earlier rate buffered housekeeping EDUs.

4.2 Science Data Operations

Nine Distributed Active Archive Centers (DAACs) representing a wide range of Earth science disciplines have been selected to carry out responsibilities for processing, archiving, and distributing EOS and related data, and for providing a full range of user support. DAACs provide custodianship for the data during and ensure that data are readily and promptly available to users. Acting in concert, the DAACs provide reliable and operationally robust services to global change researchers whose needs cross traditional discipline boundaries, while continuing to support the needs of their individual discipline communities.

EGS science data operations includes the operations capabilities to perform science data ingest, archiving, and archive maintenance; and science data processing, ordering, quality assessment, and distribution. These functions are described at a summary level in this section.

4.2.1Science Data Ingest, Archiving, and Archive Maintenance

The science data ingest, archiving, and archive maintenance function ingests and archives EOS data and selected non-EOS data at the EOSDIS DAACs, and monitors

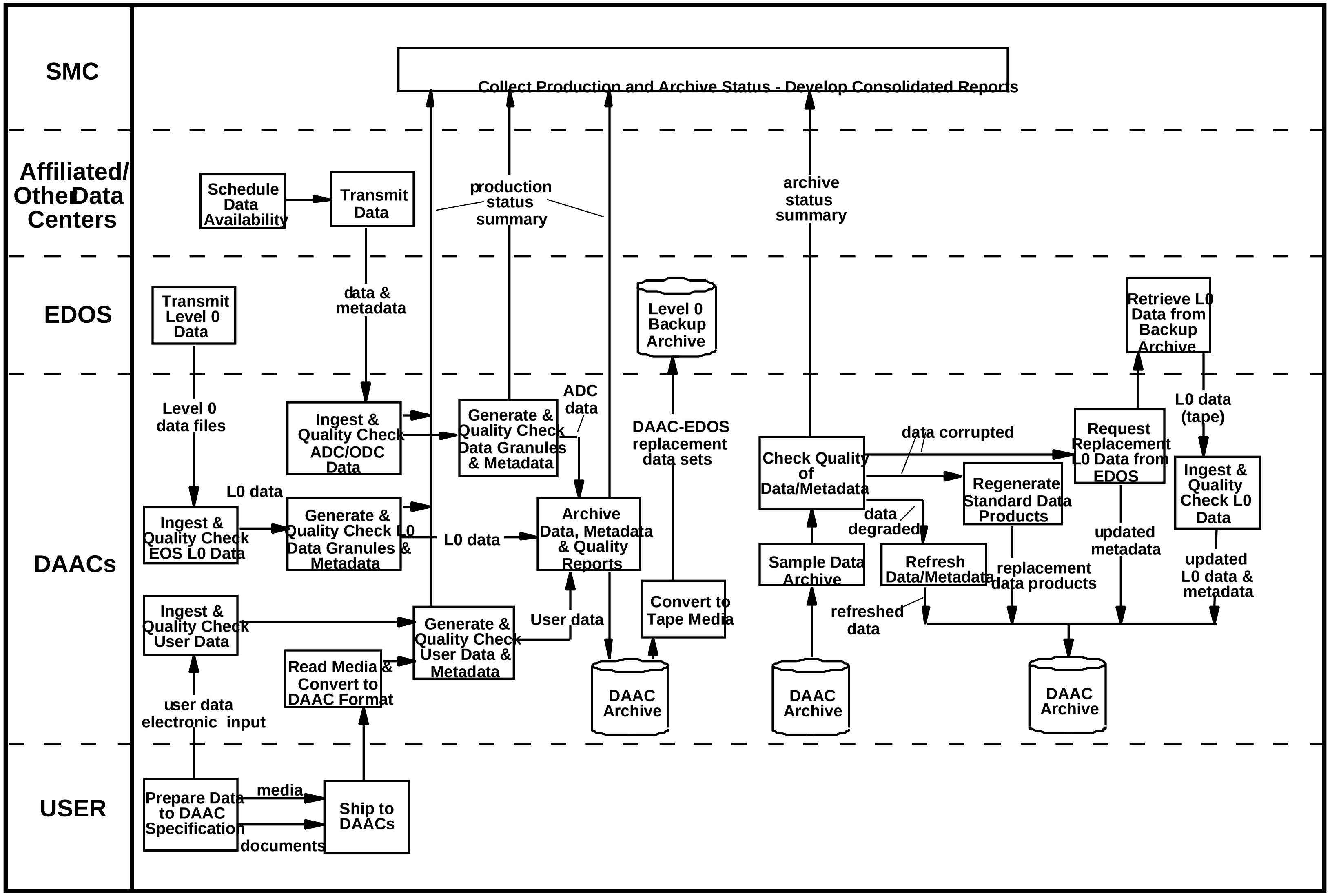

Figure 4.2.1-1 Data Ingest, Archiving, and Archive Maintenance Scenario

and maintains the integrity of the the data stored in the DAAC archives. Figure 4.2.1-1 identifies the EGS elements, participants, major interfaces, and operational processes involved in the performance of this function. Summary-level descriptions of the processes are provided in this section.

4.2.1.1 EOS Data Ingest and Archiving

The EDOS transmits EOS level 0 data files to the EOSDIS DAACs using standard, commercially available, guaranteed data delivery protocols. These protocols implement error detection and correction schemes through encoding and/or retransmission. The EOSDIS DAACs ingest EOS level 0 data files and associated ancillary data from EDOS and perform automated quality checks to verify that the data are received correctly in a time-ordered sequence with no gaps; if necessary, the DAAC requests that incomplete data be resent by EDOS.

Following the ingest process, the DAACs generate level 0 data granules (the smallest aggregation of data that is independently managed), extract the ancillary data, and create metadata that describe the level 0 granules. Automated quality checks are performed on the level 0 granules, metadata, and ancillary data for validity, internal consistency, and completeness. The level 0 data and the associated metadata and automated quality reports are entered into the DAAC archive. If level 0 data in the EDOS backup archive is lost or damaged, EDOS can request replacement of this data from the appropriate DAAC. The required data are converted to physical media and sent to EDOS as DAAC to EDOS Data sets (DEDs).

The EOSDIS DAACs routinely provide DAAC production status summary information to the System Monitoring and Coordination Center (SMC). The SMC provides the ESDIS project the capability and tools to maintain programmatic and scientific oversight and to coordinate EOSDIS DAAC resources and operations as necessary.

4.2.1.2 ADC/ODC Data Ingest and Archiving

The EOSDIS DAACs ingest and archive other NASA Earth science data from affiliated data centers (ADCs) and other data centers (ODCs) that are part of MTPE. This may include data from other earth observing projects, such as TRMM and Landsat; special projects with EOS instruments on other spacecraft, such as flights of opportunity; and non-EOS programs. Data from these sources may also be required to generate special products. The EOS Program negotiates agreements with other agencies, including international organizations, to acquire and use these data. Agreements between the ESDIS Project and the responsible source organization define the type of data and identify the appropriate DAAC to receive the data.

Data are received from ADCs and ODCs in the form of level 0, ancillary, or processed data sets, with the associated metadata, according to rules defined by the DAACs. The data generally are received electronically; however, DAACs are able to accept and read data from physical media.

DAACs and ADCs/ODCs coordinate the availability of data. ADCs/ODCs schedule their data availability and notify the DAACs with a data availability notice, which specifies the time limit that the data will be held for pickup. The DAACs schedule and perform the ingest of data from the ADCs/ODCs within the specified data availability time limits. Any deviations from the schedule are negotiated between the DAAC and the ADCs/ODCs. After ingesting the ADC/ODC data granules and associated metadata, the DAACs immediately perform automated quality checks to verify that the data specified in the data availability notice are correctly received. If necessary, the DAAC requests that incomplete data be resent.

Following the ingest and quality checking process, the DAAC extracts the identifying information from the incoming data files, combines the results of the quality check, and generates new metadata for the product. Automated quality checks are performed on the data granules, metadata, and ancillary data for validity, internal consistency, and completeness. The data granules, metadata, and automated quality report are assembled and entered into the DAAC archive, and the DAAC inventory is updated. As negotiated, level 0 data from ADCs/ODCs may be sent to EDOS as physical media for entry into the backup archive.

4.2.1.3 User Data Ingest and Archiving

Selected users may provide data, data products, analysis results, analytical software, or reports to the EOSDIS DAACs to be made available to other users. These data can be sent to the DAAC in the form of electronic files, physical media, or printed documents. DAACs ingest these data, assess their quality, convert to a DAAC compatible format as necessary, and store them with the associated metadata in the archive for use in generating products to fill user orders. User data submissions to a DAAC also may not include the complete data set, but consist of catalog and directory information identifying what data are available and how to access and order it. In this way, data holdings at a users facility are made available to the general user community without necessitating the transfer of the physical data to a DAAC.

The user logs on to a DAAC, completes the validation process, and requests to submit data from a menu of options. A local user review board at each DAAC determines which products will be allowed for submission. When the DAAC accepts the request, it provides instructions and aids to guide the user in preparing data or documents, and associated metadata for submission to the DAAC. The user prepares the materials and delivers them to the DAAC, either electronically or as hard media.

For non-electronic delivery, the user prepares the data and metadata on hard media clearly labeled with identifying information; follows the instructions provided by the DAAC to put the data in a form acceptable to the DAAC; and ships the medium to the DAAC address designated in the instructions. The DAAC reads the media and if necessary, converts it to a digital format. For hardcopy documents, the user provides a clearly labeled text document with identifying information to the address provided. The DAAC converts the text to machine-readable format.

Once the data are in an electronic format, the DAAC performs an automated quality check on the data from all sources. If the data are corrupted or not acceptable, the DAAC will request replacement data by asking the user to prepare and retransmit the data.

The DAAC extracts the identifying information from the data files, combines the results of the quality check, and generates metadata for the product. The data, metadata, and quality report are assembled and entered into the DAAC archive, and the DAAC inventory is updated.

4.2.1.4 Archive Maintenance

The EOSDIS DAACs routinely audit their data archive holdings to determine the health and status of the data in the archive; to validate the product inventory; and to maintain the data quality level of the archive.

Archive maintenance is performed by each DAAC for its data archive holdings. The data, metadata, and ancillary data are retrieved from the archive, inventory data are generated, and data product maps are prepared that cross-reference the metadata to the data granules and associated ancillary data. A product inventory database containing this information is established. In addition, the data location map is monitored for online storage utilization. Inactive files are removed, and the archive storage is compressed to maintain efficient storage utilization.

Archived data are checked to determine whether the data have degraded beyond the error limit set for the archive medium. The data are refreshed if the error limit has been exceeded, and a second check is made to determine whether the data are corrupted. If the data are corrupted, the metadata are updated to reflect the change in quality and DAAC operations personnel are alerted to initiate corrective action. If a standard data product is corrupted but the corresponding level 0 data quality is OK, then the standard data product and metadata are regenerated and placed in the archive to replace the corrupted product. If the corresponding level 0 data is also corrupted, then replacement level 0 data is requested from the EDOS backup archive
to maintain the active DAAC archives.

4.2.2 Science Data Processing, Ordering, Quality Assessment, and Distribution

The science data processing, ordering, quality assessment, and distribution function generates and archives standard data products from all EOS level 0 data; accepts user orders for data products; performs science data quality assessment; and generates and distributes products to users. Figure 4.2.2-1 identifies the EGS elements, participants, major interfaces, and operational processes involved in the performance of this function. Summary-level descriptions of the processes are provided in this section.

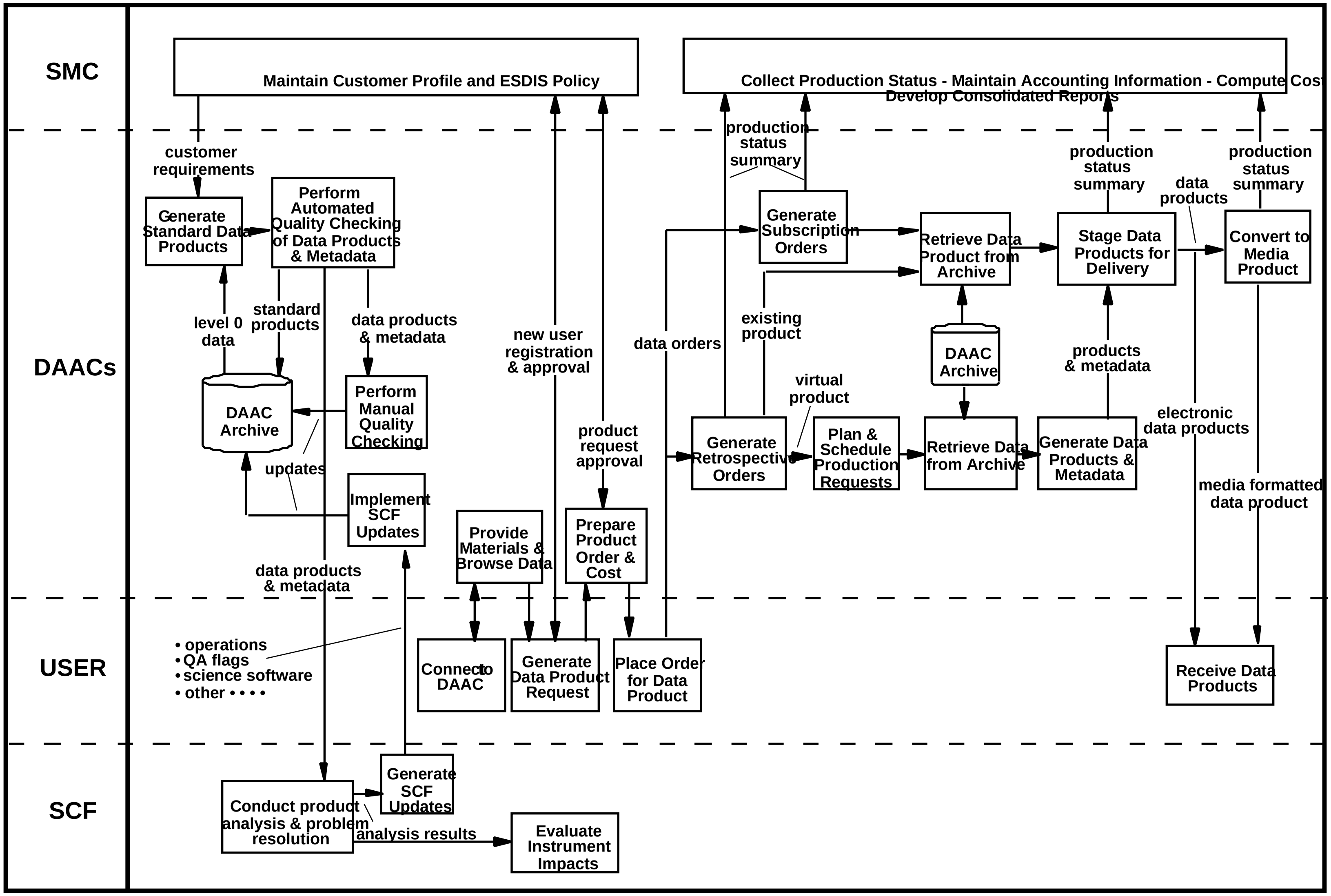

Figure 4.2.2-1 Data Processing, Ordering, Quality Assessment, and Distribution Scenario

4.2.2.1 EOS Data Processing

Following the EOS level 0 data ingest and archiving process, standard data products and associated metadata are generated from all EOS level 0 data in the DAAC archives according to a predefined set of requirements and criteria jointly established by the DAACs and the science community. An automated quality check is performed on the products and metadata; the standard products, associated metadata, and quality reports are entered into the DAAC archive, and the DAAC inventory is updated.

4.2.2.2 Product Ordering and Distribution

The EOSDIS DAACs provide a wide range of services that enable users to efficiently and effectively interact with the EOSDIS to place orders for products. These include services to: register as a user; obtain help and tutorial support; search and query data holdings; browse and order existing data granules; request acquisition of specific data; determine the status of orders; and receive products.

There are two basic types of orders processed by the DAACs; subscription orders and retrospective orders. A summary-level description of each is provided in the following sections.

4.2.2.2.1 Subscription Order Processing and Delivery

Subscription order processing is an extension of the standard data product generation and archiving process discussed in section 4.2.2.1. Subscription order processing allows authorized users to request, in advance of acquisition, all standard data products that meet their specified criteria. Whenever a user has entered a subscription order into the system, the requested standard data products are retrieved from the archive, staged for delivery, and delivered to the user automatically each time the requisite data are acquired and the standard data product is produced. The user need take no further action.

In addition to standard data products, users can also place subscription orders for level 0 products. Level 0 products are staged for delivery immediately after being assembled into a predefined format. Once staged for delivery, data products are delivered to the user electronically or as physical media. The product order and cost information are sent to the SMC where an itemized invoice is prepared and sent to the user, and the user's account is debited for the cost of the product.

4.2.2.2.2 Retrospective Order Processing and Delivery

Retrospective order processing allows users to order a data product from a list of existing and “virtual” products. A virtual product appears as an existing product to a user since metadata exists to describe it, but the product is only produced when an order for it is received. The existence of metadata indicates that all data required to produce the product is available in the DAAC archive.

To initiate a retrospective order, the user logs onto the system, is validated as an approved user, and an interactive session is initiated between the user's workstation and the DAAC. At the beginning of the session, the user is notified of the status of any outstanding orders in their account. The user then selects and reviews the appropriate data catalogs, identifies the data desired, and requests the corresponding metadata. The requested metadata are provided to the user's workstation regardless of which DAAC the metadata resides in; the location of the desired metadata is transparent to the user. The user examines the metadata and generates a data product request.

The DAAC computes the price of providing the requested product, queries the user's account in the SMC to verify that the user has the proper data access authorization and that sufficient funds are available in their account to pay for the product. The DAAC then returns either an itemized product order and estimated price to the user, or rejects the product request and identifies the reason for the rejection. The user then places an order or terminates the session.

If an order is initiated, the DAAC determines whether the requested product is available directly from a DAAC archive. If available, the DAAC retrieves the requested product from the archive and stages the product for delivery. The location of the data product is transparent to the user; it may be located in any DAAC. If the requested product is not available directly from the archive but must be specially produced, the DAAC determines what additional processing is required, plans and schedules a production request for the product, retrieves and stages the necessary data, and produces the required product and associated metadata. If desired, and the user has the proper approval, their retrospective order may be converted into a subscription order so that from that time on, the DAAC will automatically produce the special product whenever the data necessary to produce it is available, and ship it to the user with no further action required by the user.

After the product is produced, product quality is automatically assessed against predefined criteria and a quality report is generated. Product metadata are updated; and the new product, its corresponding metadata, and quality report are staged for delivery. Once staged for delivery, data products are delivered to the user, electronically or on physical media. The product order and cost information are sent to the SMC, where an itemized invoice is prepared and sent to the user, and the user's account is debited for the cost of the product.

The EOSDIS DAACs routinely provide DAAC production status summary information to the System Monitoring and Coordination Center (SMC). The SMC provides the ESDIS Project the capability and tools to maintain programmatic and scientific oversight and to coordinate EOSDIS DAAC resources and operations as necessary.

4.2.2.3 Science Data Quality Assessment

Science data quality assessment is performed on instrument data as part of routine instrument performance evaluation, and processed data are examined to assess the accuracy of the science algorithms provided by investigators and to evaluate EOSDIS DAAC system performance. All instrument data and data products are routinely screened, and subsets of the data are subjected to in-depth analysis.

The scenario depicted in Figure 4.2.2-1 represents the period well after instrument activation when both instrument performance and related standard data product generation software are well understood. The scenario is limited to quality assessment of standard data products. That is, data quality assessment processes applied to other science data types, such as ancillary data, Version 0 data, or other external datasets, are not considered here but are expected to be similar. Three levels of quality assessment are performed to monitor and evaluate the various science data products produced during production operations.

The first level, automated quality screening, incorporates software-based screening routines embedded in the science software to automatically evaluate all generated products and identify those products that do not meet predefined assessment criteria defined by the instrument team. The quality of the data products is recorded on production processing summary reports, and product metadata is updated as a result of the automatic screening. Production history logs record the complete history of each production job to facilitate the resolution of processing anomalies or other abnormal results.

The second level is performed by trained DAAC operations personnel, using more sophisticated quality assessment tools and procedures. This level of assessment is generally performed whenever the automated quality screening produces a non-nominal result, as well as on a procedural basis where samples of data products are routinely subjected to a more in-depth quality assessment. DAAC personnel examine production history logs, product metadata, and the actual data products as necessary to identify data quality problems and isolate their cause. The DAAC personnel determine if a real data or processing software problem exists, or whether some other reason is the cause. The problem may, for example, only be a configuration control problem, such as the use of an incorrect calibration file. In that case, DAAC personnel schedule the necessary reprocessing and delete the incorrect products from the system. If a genuine data or processing algorithm problem exists that the DAAC personnel cannot resolve, they notify the instrument team of the situation.

Finally, instrument teams at the SCFs perform the third and highest level of data quality assessment. In order to monitor changes in instrument performance and record long term trends, the instrument team places subscription orders for selected data products which are automatically produced and sent to the instrument team for in-depth quality assessment The instrument teams at the SCFs also perform the in-depth analysis that may be necessary to determine the cause of a data or processing software problem. These problems may be detected as a result of the previous quality screening activities, or may result when the users of data products report product anomalies discovered in the process of using the data in their work.

As with the potential causes of a data problem, multiple solutions are possible. Some problems may be corrected with updated calibration files, minor adjustments to algorithms, or modifications to data formatting routines. Other problems may be caused by systems outside the control of the instrument team. Instrument or spacecraft problems may require the development of entirely new algorithms to correct the problem. Certain types of spacecraft problems may require an evaluation of the impact on the instrument, and may necessitate changes to the way the instrument or spacecraft is operated or scheduled. Updates to the screening routines may be required to eliminate false alarms on data quality or to introduce additional checks not planned for during initial development. Reprocessing of some of the instrument data may be necessary because of changes in software or calibration parameters.

The PI or TL will coordinate with the project scientist to arrange for the allocation of resources and schedules for any required reprocessing. Product metadata will be updated to reflect changes in data quality assessment, as required. Users will be notified when data products they have previously received are determined after the fact to have quality problems.

4.3 EGS Monitoring and Coordination

EGS monitoring and coordination equals EOSDIS monitoring and coordination plus monitoring of and coordination with other EGS element interfaces. It is comprised of two components; local EGS management and coordination, and EGS system-level monitoring and coordination. It includes the operations capabilities to provide EGS-wide operations status and performance reporting; provide centralized billing and accounting; maintain current ESDIS policies and procedures; and coordinate EGS-wide problem analysis and resolution as necessary. Figure 4.3-1 identifies the EGS elements, participants, major interfaces, and operational processes involved in the performance of the EGS monitoring and coordination function. A summary-level description of this function and its capabilities is presented in this section.

4.3.1 Local EGS Management and Coordination

The local EGS management and coordination function provides local domain specific management and operations and inter-domain coordination via ECS provided local system managers (LSMs). LSMs provide local management services to manage the ECS-provided capability and resources at each distributed ECS site (i.e., the DAACs and the EOC). Each ECS site and element, through its LSM component, schedules and performs its own internal real-time operations and resource management functions, subject to coordination from the System Monitoring and Coordination Center (SMC).

In addition to the ECS LSM functions, local operations management functions internal to EDOS, EBnet and the external network, and other EGS elements schedule and perform the internal real-time operations and resource management of those elements. Each element has the capability to exchange a wide range of status and

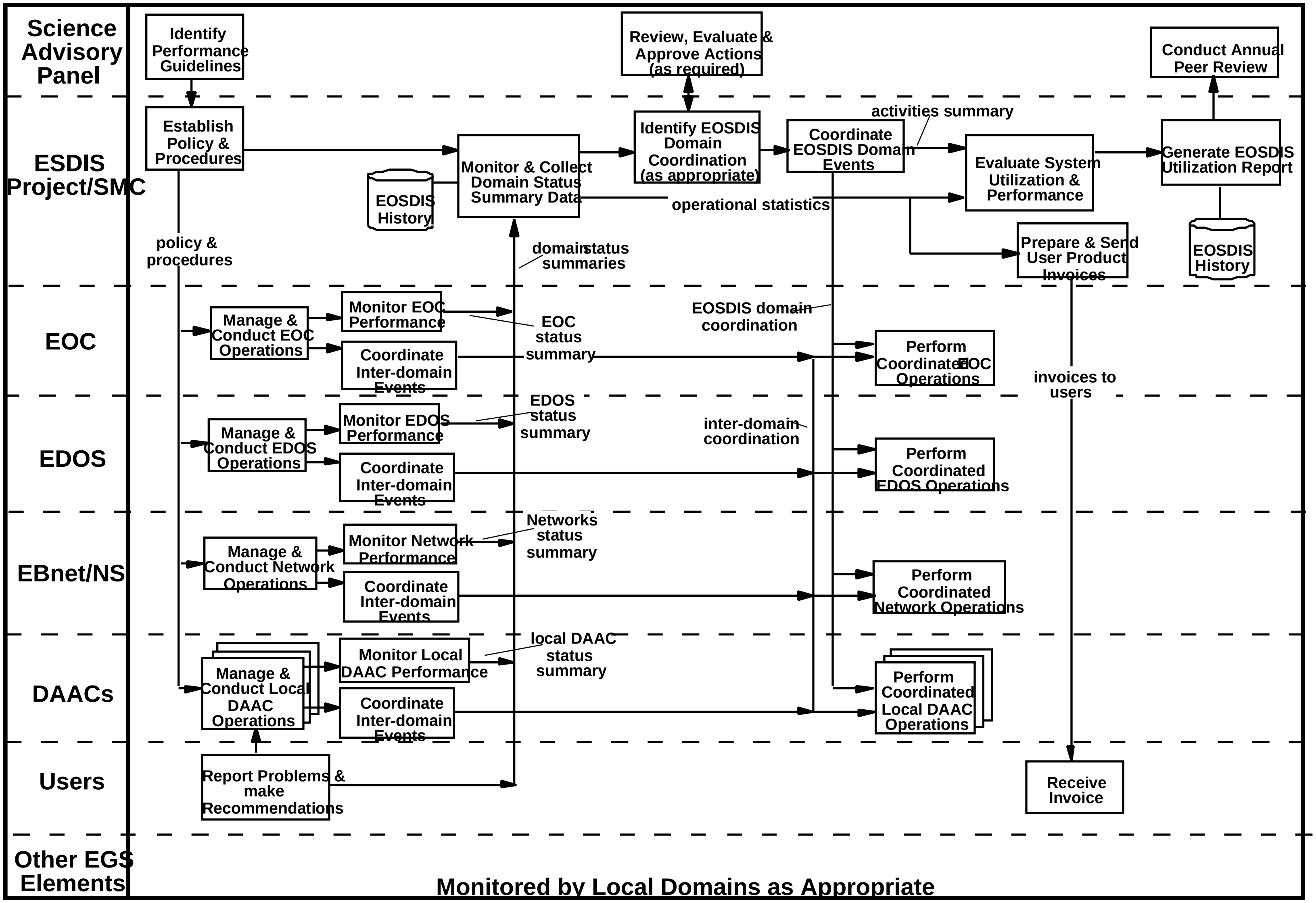

Figure 4.3-1 EGS Monitoring and Coordination Scenario

coordination data with the SMC. Each element can also perform inter-domain coordination by exchanging status and coordination information directly, not via the SMC. In this manner, EGS elements can resolve local issues without SMC involvement. EOSDIS local domains also provide status information to the SMC pertaining to their external interfaces with other EOSDIS domains, institutional service providers, or other end users, allowing the SMC to maintain a current system-wide view of the EGS operational status.

4.3.2 EGS System-level Monitoring and Coordination

The EGS system-level monitoring and coordination function enables the ESDIS project to maintain a current EGS-wide operational view and perform EOSDIS system-level monitoring and coordination. EOSDIS real-time operations management services are performed by the three major operational EOSDIS elements, the ECS, EDOS, and EBnet. Each of these elements manages its own internal real-time operations and their interactions with external elements, and interacts with the other elements to coordinate and facilitate end-to-end EGS non-real-time system management. The ESDIS project maintains a current view of interactions with external EGS elements and coordinates with them when necessary. The ESDIS project role is to oversee, monitor, and coordinate when necessary with minimum interference in internal domain operations.

The focal point for EGS monitoring and coordination is the System Monitoring and Coordination Center (SMC), a component of the ECS. The SMC provides the tools and capabilities necessary to perform the monitoring and coordinating of ECS resources at the individual site level and for EOSDIS system-wide resources. The SMC monitors operations of all distributed ECS sites via LSMs, and coordinates as necessary. The SMC collects, collates, and assesses operations management data across the end-to-end EOSDIS to provide system level reporting and inter-element operations coordination as necessary. The SMC generates a wide variety of operational and administrative reports for the ESDIS project in support of day-to-day EGS operations management. The SMC also provides the data necessary to support the annual peer review assessment by the Science Advisory Panel of product use, system use, and user satisfaction.

Some of the key services provided by the SMC are: maintaining ESDIS policies and procedures; billing and accounting; scheduling; configuration management; performance management; fault management; security management; and operations analysis. Summary-level descriptions of these services are provided in this section.

4.3.2.1 Maintaining ESDIS Policies and Procedures

The SMC is the focal point for maintaining and distributing ESDIS policy, procedures and directives. Current ESDIS policy and procedures are maintained using office automation tools. Policy, procedures, directives, updates, and advisories are distributed via document data server, EMail, and bulletin board.

4.3.2.2 Scheduling

The scheduling process provides system-wide planning for and scheduling of ground events. Ground events are typically defined as non-production activities such as maintenance, testing including mission level testing and simulations, demonstrations, software upgrades, etc. The SMC will develop candidate plans for activities which impact multiple sites, and send the plans to the sites for integration into their production plans. The process supports scheduling of non-ECS events which impact ECS resources. The SMC will adjudicate conflicts with sites or between sites by supporting sites in resolving conflicts, setting priorities, and allocating resources. The SMC will develop high level plans for site resource utilization; provide a framework within which sites allocate resources for production and user support; identify bottlenecks for common resources such as network bandwith; and identify resource requirements for scheduled ground events.

4.3.2.3 Billing and Accounting

The SMC receives billing and accounting information from DAACs. This includes details of user activity from each DAAC. ESDIS policy dictates common and standard pricing for products across DAACs. Based on this policy, the SMC generates and distributes bills and utilization information to registered users; receives direct payments from registered users; receives indirect payment from DAACs (if DAACs are permitted to accept payment); maintains account limits and balances for registered users; and provides limit and balance information to DAACs.

4.3.2.4 Configuration Management

The configuration management process maintains and manages the operations baseline configuration at local sites, assesses and approves configuration changes with potential system-wide impacts prior to local implementation, manages system-wide configuration upgrades, and audits local configuration status as required.

4.3.2.5 Performance Management

The performance management process provides performance criteria and metrics to all EOSDIS elements; establishes site level performance reporting criteria; monitors and evaluates EOSDIS site and element performance and performance trends; generates fault or degradation alerts; and compiles and assesses system-wide performance data to coordinate corrective action as necessary.

4.3.2.6 Fault Management

The fault management process provides real-time support for fault isolation, diagnosis, analysis, and recovery coordination; provides a common point of contact to external systems; identifies and isolates EOSDIS site and element fault conditions; provides system-level coordination as required to resolve faults; and compiles and evaluates system-wide fault history to recommend changes if needed.

4.3.2.7 Security Management

The security management process disseminates security policy; detects and monitors security events, including breach attempts, at the local element level and coordinates action across system elements as required; notifies all EOSDIS elements of any site breach attempt or other major security event; and coordinates security matters with external security agents as necessary. The SMC collects security status information from all EOSDIS elements for use in evaluating the effectiveness of the EOSDIS-wide security process.

4.3.2.8 Operations Analysis

The operations analysis process generates a wide-range of summary operations reports to ESDIS. The SMC collects DAAC operations statistics such as: planned versus actual throughput; production and reprocessing backlog; registered and guest user activities; product request summaries; performance statististics; and resource faults and failures. The SMC collects statistics on external system interface performance such as network performance and data delivery metrics; billing and accounting summaries; and sustaining engineering activities; configuration status; system-wide security status summaries; and system-wide fault histories.

4.4 Operations Support

In addition to the operations functions described in Sections 4.1, 4.2, and 4.3, the EOSDIS elements perform several major operations support functions required to carry out EOS mission operations. These functions include sustaining engineering; system maintenance; EOSDIS configuration management; data management; training and certification; and operations readiness verification.

Element operations and maintenance (O&M) organizations provide the resources required to perform operations support functions, including the administrative and management functions necessary to operate element facilities. The EOSDIS development contractors maintain and operate the EOSDIS systems until these responsibilities transfer to the O&M organizations. The EOSDIS development contractors support this transition by providing training, up-to-date documentation, supporting data and information, and any special software or other tools required to maintain the operational systems.

The EOSDIS operations support functions are summarized in this section.

4.4.1 Sustaining Engineering

The EOSDIS sustaining engineering function monitors system-level operations and analyzes trends in performance, capacity, and reliability, maintainability, and availability (RMA); maintains system-level requirements and evaluates the impact of proposed changes in EOSDIS requirements; assesses the capabilities of new technologies and their possible application by EOSDIS; provides technical assistance in resolving problems, as required; and coordinates the planning, implementation, and integration of major upgrades as EOSDIS evolves over its operational life. The ESDIS Project provides a system-level capability that coordinates the sustaining engineering functions performed by each EOSDIS element and performs system-level sustaining engineering activities.

The EOSDIS elements provide tools and other capabilities to support element and system-level sustaining engineering activities. The implementation of these capabilities varies among EOSDIS elements. At ECS, sustaining engineering personnel share development facility resources; sustaining engineering capabilities will be established for long-term operational support. EDOS and EBnet have dedicated non-operational resources that provide sustaining engineering functions. Other EOSDIS elements allocate hardware and software components from their overall system configuration as necessary to support sustaining engineering activities.

4.4.1.1 Operations Monitoring and Trend Analysis

The sustaining engineering function in each EOSDIS element monitors its internal operations and evaluates its system performance and resource utilization in supporting EOS mission operations. The methods and procedures used at each site are described in detail in the applicable system design documentation and operations manuals.

Each element also provides summary status and performance reports and operations management data to the SMC for use in evaluating overall system performance and performing trend analyses to predict future operations requirements. Trend information will be used to revise system-wide policies and procedures, in order to maximize EOSDIS end-to-end performance.

4.4.1.2 Impact Analysis and Technology Assessment

EOSDIS sustaining engineering personnel maintain the system-level requirements and evaluate the impact of proposed changes to these requirements on EOSDIS's ability to support new and ongoing EOS missions. EOSDIS sustaining engineering personnel also evaluate developments in computer system, communications, and other technologies that may be used to meet current or future system requirements. Changes are typically recommended to enhance EOSDIS mission support functions or performance, expand system capacity, improve system or element RMA, or reduce life-cycle costs.

4.4.1.3 System Evolution Planning and Coordination

The ESDIS project coordinates the efforts of the EOSDIS elements in defining, planning, integrating, and testing major system releases. Major system releases may include, for example, the addition of system functionality and capacity to support new missions or other changes in support requirements; integration of new technologies to improve system performance; and simultaneous installation of a number of maintenance changes to correct system errors and deficiencies.

Each EOSDIS element is responsible for developing and testing system changes and for verifying system-level functional, performance, and interface capabilities prior to installation in the operational system. The SMC coordinates inter-element tests, including independent verification and validation activities and operational readiness tests, as required. The SMC also coordinates the transition activities and schedules for installing each major release in the EOSDIS operational configuration.

4.4.2 System Maintenance

System maintenance includes the resources, personnel, equipment and tools, documentation, and logistics support required to identify, design, fabricate or acquire, install, and test all changes to EOSDIS hardware, software, and firmware, and the logistics and administrative support required to support these activities.

Each EOSDIS element's O&M organization is responsible for performing the system maintenance activities required to correct defects and errors, perform preventive maintenance procedures to support system operations, install vendor-provided field modifications, and implement changes required to enhance system capabilities and maintain compatibility with other EOS systems. At the DAACs and other facilities that host EOSDIS functions, maintenance of these functions is performed by the host organization or shared between host and EOSDIS in accordance with the support arrangements applicable to each site.

Each EOSDIS site provides summary reports of maintenance plans, schedules, and status to the SMC, which maintains an EOSDIS-wide maintenance schedule and master system configuration records for EOSDIS systems. Integration of all EOSDIS system changes into end-to-end EGS operations is coordinated by the SMC to minimize the impact to ongoing EOS mission support.

All changes to operational EOSDIS elements made during system maintenance are verified before installation in the operational system. System maintenance is planned, scheduled, and executed at the element level in accordance with ESDIS project policies and guidelines. The SMC maintains a master list of EOSDIS maintenance plans and schedules and coordinates the schedule for integrating maintenance changes at the operations level, to ensure that there is no interruption to EOS mission support

Logistics support for the EOSDIS elements is performed at each site in accordance with NASA and ESDIS Project policies and with the logistics requirements specified by each element's development organization. Local site managers are responsible for providing the spares and expendables needed to sustain site O&M functions to meet EOSDIS mission operations support requirements. Each site maintains utilization and status information about its logistics activities and provides summary reports to the SMC for use in system-wide logistics monitoring, trend analysis, and coordination.

4.4.3 EOSDIS Configuration Management

EOSDIS operational resources are controlled through a configuration management process, in accordance with ESDIS project policies and guidelines. The configuration of each EOSDIS element is frozen at the time of operational acceptance. Each element is responsible for maintaining the configuration of its system components and the associated documentation; tools, equipment, and materials; and facilities. Each element has established configuration control procedures consistent with ESDIS policies.

The ESDIS project coordinates the integration of all changes to EOSDIS elements in the end-to-end system configuration. Changes are installed at local sites after all pre-installation and verification activities are completed, and with the approval of the ESDIS project. Operations data, tools, and updated documentation are migrated to the operational environment along with the associated hardware and software.

The ESDIS Project configuration control board maintains system-level configuration control of all EOSDIS elements. The SMC maintains a master configuration list for all EOSDIS operational system components. Element configuration status reports are provided to the SMC for use in maintaining a configuration change audit trail, generating configuration change reports, and updating the master list.

4.4.4 Data Management

The ESDIS Project data management function is used to generate, identify, control, and distribute the engineering and technical management information required to support the Project. The data management function includes the establishment and enforcement of uniform standards for document and data formats, access and maintenance, and control over changes and updates.

The data management processes established during EOSDIS development are used throughout the EOSDIS life cycle to maintain the currency of EOSDIS documentation and technical data, and to make these materials available to ESDIS Project staff, EOSDIS O&M personnel, and EOS users to support execution of their EOS responsibilities.

4.4.4.1 Documents and Technical Materials

The accuracy and currency of the information developed during EOSDIS implementation must be maintained to ensure the integrity of this information over the EOS Program's planned 20-year lifetime. Master copies of all project management policies and procedures, study reports, and EOSDIS elements' system and operations documentation are maintained at specific EOSDIS facilities, as appropriate.

All relevant materials are updated, or new materials prepared or procured, whenever system components or operational capabilities or procedures are modified or replaced. All documentation updates are made in accordance with configuration management procedures. Distribution lists are maintained for the various classes of documentation, and notifications of the availability of updates and materials are disseminated accordingly.

4.4.4.2 System Operations Data

The integrity of each element's data bases, software, and other system-resident information is critical to sustain EOS operations and maintain confidence in the results of EOS-based research.

The EOSDIS data management function provides for safeguarding the accuracy and currency of these materials.

Master and backup copies of each EOSDIS element's system software and firmware, applications software, the contents of operational data bases, and other system-resident information are maintained at element facilities and at designated alternate sites. Master and backup copies of centralized EOSDIS system operations information are maintained by the ESDIS project data management function and made available to the appropriate EOSDIS elements in accordance with project configuration management procedures.

4.4.4.3 Science Data

Protecting EOS science data while making it available for scientific research is a crucial challenge for EOSDIS data management. The process for establishing and maintaining the EOSDIS science data archive is summarized in Section 4.2.1.

4.4.5 Training and Certification

The EOSDIS elements provide for the training and certification of element personnel, both Government and contractor, in the operation and maintenance of their operational systems and in executing auxiliary activities as required.
Training is conducted at the appropriate site(s) in accordance with an approved training plan, without interfering with EOS operations. All personnel receive instruction to familiarize them with the overall EOS program and with EOSDIS and local security requirements and procedures, in addition to specialized training tailored to the responsibilities of each job classification. Periodic refresher training and recertification is conducted for all O&M positions to maintain and improve the operational knowledge and skills of current staff.

Each element's training program includes formal classroom presentations and laboratory training; on-the-job training; self-study courses to supplement formal training courses; and vendor-provided training courses for EOSDIS equipment, where applicable. Simulators, test systems, and other training tools and methods to provide hands-on practice are used wherever practical. A formal certification process tests the students' grasp of essential materials and demonstrates their proficiency at performing the duties of the position for which they are being trained.

4.4.6 Operations Readiness Verification

EOSDIS operations readiness verification is the culmination of EOSDIS system integration and test activities. EGS readiness to support launch and mission operations for each EOS mission is demonstrated by successful acceptance testing at each element; compatibility tests between EOSDIS elements and other EGS facilities; and mission simulations to validate operations procedures and to provide a realistic environment for completing operator training. The EOSDIS then participates in tests conducted to verify the operational readiness of the entire EOS operational system to support the new mission and maintain ongoing operations.

Operations readiness tests consist of informal and formal end-to-end tests to exercise the full range of spacecraft and ground system capabilities. Informal tests include real-time data flows to test the mission-critical elements of the EOSDIS and other EGS capabilities, and to determine the effectiveness of operations plans and procedures and personnel training. Tests of the data processing elements use live or recorded instrument data as input, to verify that the science algorithms to be used in standard data production produce the expected output.

Formal operations readiness tests consist of end-to-end data flows based on realistic mission operations scenarios. All EOSDIS elements and other facilities required to support the test are configured as for live mission support. The operations staff at each facility executes the mission support activities specified in the test script. The mission's instruments and other spacecraft components, or data recorded from them, are used whenever possible to ensure that the spacecraft and ground system are fully compatible under operational conditions. Each scenario is executed to completion; test logs are maintained at each facility and test output and other results are recorded for post-test analysis. A full debriefing of each test is conducted to verify the results, evaluate anomalies, and identify any required corrective actions and retesting.

The results of operations readiness testing and other operations readiness verification activities are presented by the MOM at the mission Operations Readiness Review, typically conducted about 90 days before the scheduled launch readiness date.

Abbreviations and Acronyms

ADC affiliated data center
ADD architecture description document
ADEOS Advanced Earth Observing Satellite mission series (Japan)
AM EOS Morning (AM) Crossing Mission series
AM-1 first spacecraft in the EOS AM series
AOS acquisition of signal
APID applications process identifier
ASTER Advanced Spaceborne Thermal Emission and Reflection Radiometer (Japanese instrument)

CCB configuration control board
CCSDS Consultative Committee for Space Data Systems
CEOS Committee on Earth Observing System
CERES Clouds and Earth's Radiant Energy System (U.S. instrument)
CHEMEOS Chemistry Mission series
CIESIN Consortium for International Earth Science Information Network
CLCW command link control word
CLTU command link transmission unit
CSMS Communications and System Management Segment (ECS)

DAAC Distributed Active Archive Center
DAR data acquisition request
DCN document change notice
DED DAAC-to-EDOS data set
DSN Deep Space Network

EBnet EOSDIS Backbone Network
Ecom EOS Communications Network **[not current terminology]**
ECS EOSDIS Core System
EDOS EOS Data and Operations System
EDS expedited data set
EDU EDOS data unit
EGS EOS Ground System
ENVISAT POEM environmental satellite series (ESA)
EOC EOS Operations Center (ECS)
EOS Earth Observing System
EOSDIS Earth Observing System Data and Information System
ESA European Space Agency
ESDIS Earth Science Data and Information System (GSFC)
ESDT Earth Science Data Type

ESOC	EOSDIS System and Operations Concept (document)
ETS	EOSDIS Test System
FD	Flight Dynamics
FOO	flight of opportunity
FOS	Flight Operations Segment (ECS)
FOT	flight operations team
GAO	General Accounting Office
GCRP	Global Change Research Program
GN	Ground Network
GSFC	Goddard Space Flight Center
HK	housekeeping
IAP	instrument activity plan
ICC	instrument control center
ICWG	International Coordinating Working Group
IEOS	International Earth Observing System
ILS	integrated logistics support
IP	international partner
IRD	interface requirements document
IST	Instrument Support Terminal (ECS)
IWG	investigator working group
JEOS	Japanese Earth Observing System
KSA	Ku-band single access
L0	level 0 (data)
L1A	level 1A (data)
LALT	EOS Laser Altimeter mission series
LAN	local area network
Landsat	Land Remote-Sensing Satellite
LOS	loss of signal
LPS	Landsat Processing System
LSM	local system management (ECS)
LTIP	long-term instrument plan
LTMP	long-term mission plan
LTSOP	long-term spacecraft operations plan
LTSP	long-term science plan
METOP	POEM meteorological satellite series (ESA)
MOM	Mission Operations Manager
MTPE	Mission to Planet Earth
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency (Japan)
NCC	Network Control Center (GSFC)

NOAA National Oceanic and Atmospheric Administration
NSI NASA Science Internet

O&M operations and maintenance
ODC other data center
OM operations management (data)
OT observation time

PDS production data set
PI principal investigator
PM EOS Afternoon (PM) Crossing Mission series
PMP project management plan
POEM Polar-Orbit Earth Observation Mission
PSCN Program Support Communications Network

QA quality assurance
QC quality control

RMA reliability, maintainability, and availability
RT real-time

SAP Science Advisory Panel
S/C spacecraft
SCF Science Computing Facility
SDC source data center
SDPF Sensor Data Processing Facility (GSFC)
SDPS Science Data Processing Segment (ECS)
SMC System Management and Coordination Center (ECS)
SN Space Network
SNC Space Network Control
SSA S-band single access

TBD to be determined
TDRS Tracking and Data Relay Satellite
TDRSS Tracking and Data Relay Satellite System
TL team leader
TONS TDRS On-board Navigational System
TOO target of opportunity
TRMMTropical Rainfall Measuring Mission
TSDIS TRMM Science Data and Information System
TSS TDRS service session
TW target week

U.S. United States
UARS Upper Atmosphere Research Satellite
UPM user performance message
UTC universal time coordinated

VCDU	virtual channel data unit
WCRP	World Climate Research Program
WOTS	Wallops Orbital Tracking Station
WSC	White Sands Complex (New Mexico)
WWW	World Wide Web

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Glossary

The entries in this glossary are adapted from the Earth Observing System Data and Information System Glossary available on the project server, updated most recently on November 2, 1994. The "Source" notations have been carried over to retain the original references:

ECS	EOSDIS Core System (project)
EPO	EOS Project Office
ESAD	Earth Science and Applications Division
ESADS	Earth Science and Applications Data System (project)
ESDIS	Earth Science Data and Information System (project)
IWGDMGC	Interagency Working Group on Data Management for Global Change
SPSO	Science Processing Support Office

AFFILIATED DATA CENTER (ADC) A facility not funded by NASA that processes, archives, and distributes Earth science data useful for Global Change research, with which a working agreement has been negotiated by the EOS Program. The agreement provides for the establishment of the degree of connectivity and interoperability between EOSDIS and the ADC needed to meet the specific data access requirements involved in a manner consistent and compatible with EOSDIS services. Such data-related services to be provided to EOSDIS by the ADC can vary considerably for each specific case. Source: EPO

AFFILIATED USER A user who is sponsored by one of the parties to the Earth Observations ICWG (EO-ICWG) data policy. Each party is responsible for ensuring that all its affiliated users comply with the EO-ICWG data policy. Use of data by affiliated users is classified in one of three categories, defined in the EOICWG data policy. Source: EPO

ALGORITHM 1) Software delivered to the SDPS by a science investigator (PI, TL, or interdisciplinary investigator) to be used as the primary tool in the generation of science products. The term includes executable code, source code, job control scripts, as well as documentation. 2) A prescription for the calculation of a quantity; used in Earth system science to derive physical or biological properties from observations and to facilitate calculation of state variables in models. Source: ECS

ATTITUDE The orientation of the sensor along with information about the accuracy and precision with which this orientation is known. This information is required to perform proper calibration of instrument data. The attitude is usually stored in Euler angle or quaternion form and may be calculated by the on-board computer and telemetered to the ground, or by ground processing facilities (e.g., GSFC Flight Dynamics Facility) using a variety of attitude sensor data.

AUTHORIZED USER A user who has viable EOSDIS accounts and who may therefore make EOSDIS data requests; may be Affiliated or Unaffiliated. See also USER.

BROWSE A representation of a dataset or data granule used to pre-screen data as an aid to selection prior to ordering. Also, a data set, typically of limited size and resolution, created to rapidly provide an understanding of the type and quality of available full resolution data sets. It may also be used to select intervals for further processing or analysis of physical events. For example, a browse image might consist of a reduced resolution version of a single channel from a multi-channel instrument. Note: Full resolution data sets may be browsed. Source: SPSO, ESADS

BROWSE DATA PRODUCT Subsets of a larger data set, other than the directory and guide, generated for the purpose of allowing rapid interrogation (i.e., browse) of the larger data set by a user. For example, the browse product for an image data set with multiple spectral bands and moderate spatial resolution might consist of an image in two spectral channels, at a degraded spatial resolution. The form of browse data is generally unique for each type of data set, and depends on the nature of the data and the criteria used for data selection within the relevant scientific disciplines. Source: EPO

CALIBRATION DATA The collection of data required to calibrate the instrument science and engineering data, and the spacecraft or platform engineering data. It includes pre-flight calibrator measurements, calibration equation coefficients derived from calibration software routines, and ground truth data that are to be used in the data calibration processing routine. Source: ECS

CO-INVESTIGATOR An individual selected by the PI who typically provides support in preparing the proposal and who has specific responsibilities in the development, operations, or analysis phases of the investigation. Source: ESADS

COMMAND Instruction for action to be carried out by a space-based instrument or spacecraft.

CONFIGURATION The functional and physical characteristics of hardware, firmware, software or a combination thereof as set forth in technical document and achieved in a product.

CONFIGURATION CONTROL The systematic proposal, justification, evaluation, coordination, approval or disapproval of proposed changes, and the implementation of all approved changes in the configuration of a configuration item after formal establishment of its baseline.

CORRELATIVE DATA Scientific data from other sources used in the interpretation or validation of instrument data products, e.g. ground truth data and/or data products of other instruments. These data are not utilized for processing instrument data. Source: ESADS, EPO

DATABASE 1) A collection of data sets with supporting metadata related to a system, project or facility. 2) A collection of integrated data serviced by a data base management system (DBMS); often organized for quick search and retrieval. Source: ESAD

DATA ARCHIVE A facility providing indefinitely long storage, preservation, disposition, and distribution of data sets and associated metadata. Source: ESADS

DATA PRODUCT A collection (one or more) of parameters packaged with asso-ciated ancillary and labeling data. uniformly processed and formatted, typically with uniform temporal and spatial resolution. Often, the collection of data distri-buted by a data center or subsetted by a data center for distribution. Source: SPSO

There are two types of data products:

Standard - A data product produced at a DAAC by a community consensus algorithm. Typically produced for a wide community. May be produced routinely or on-demand. If produced routinely, typically produced over most or all of the available independent variable space. If produced on-demand, produced only on request from users for particular research needs typically over a limited range of independent variable space. Source: SPSO

Special - A data product produced at a Science Computing Facility by a research status algorithm. May migrate to a community consensus algorithm at a latter point. If adequate community interest, may be archived and distributed by a DAAC. Source: ESDIS

DEEP SPACE NETWORK (DSN) The network of NASA ground stations normally used to communicate with deep space probes or high- altitude satellites. The DSN can provide backup communications with low Earth-orbiting satellites. Source: EPO

DETAILED ACTIVITY SCHEDULES The schedule for a spacecraft and instruments which covers up to a 10 day period and is generated/updated daily based on the instrument activity listing for each of the instruments on the respective spacecraft. For a spacecraft and instrument schedule the spacecraft subsystem activity specifications needed for routine spacecraft maintenance and/or for supporting instruments activities are incorporated in the detailed activity schedule.

DIRECTIVES Directives consist of information received by the PGS from the system management center that acts as a final authoritative directive for action. It may include general policies, official procedures, and resolutions of schedule conflicts that have not been resolved with the IMS.

DISTRIBUTED ACTIVE ARCHIVE CENTER (DAAC) An EOSDIS facility that generates, archives, and distributes EOS Standard Data Products, and related information, for the duration of the EOS mission. An EOSDIS DAAC is managed by an institution such as a NASA field center or a university, under terms of an agreement with NASA. Each DAAC contains functional elements for processing data [the Product Generation System (PGS)], for archiving and disseminating data (the DADS), and for user services and information management (elements of the IMS). Other (non-NASA) agencies may share management and funding responsibilities for the active archives under terms of agreements negotiated with NASA. Source: EPO

The EOS DAACs include: ASF (Alaska SAR Facility), EDC (EROS Data Center) GSFC (Goddard Space Flight Center), JPL (Jet Propulsion Laboratory), LaRC (Langley Research Center), MSFC (Marshall Space Flight Center), and NSIDC (National Snow and Ice Data Center).

EXPEDITED DATA Data available for examination within a short time of receipt, where completeness of processing is sacrificed to achieve rapid availability. Source: ESADS

EXPEDITED DATA SET (EDS) Data sets generated by EDOS using raw instrument or spacecraft packets from a single Tracking and Data Relay Satellite System (TDRSS) acquisition session and made available for delivery to a user within one hour of receipt of the last packet in the session. Transmission artifacts are removed, but time ordering and duplicate packet removal are limited to packets received during the TDRSS contact period.

EOS PROGRAM The activity that provides the long-term observations and the supporting information system necessary to develop a comprehensive under-standing of the way the Earth functions as a natural system. The EOS Program Office and the EOS Project are included in the EOS Program. Source: EPO

EOS PROGRAM DIRECTOR The NASA Headquarters official who is the focal point for all Headquarters activities bearing on the EOS Program. Source: EPO

EOS PROGRAM OFFICE The EOS Program Director and his staff. The EOS Program Office is located at NASA Headquarters. Source: EPO

EOS PROGRAM SCIENTIST The NASA Headquarters official assigned to the EOS mission. The roles and responsibilities of this function are defined in NMI 7100.11. One of them is to establish the policies for the analysis, dissem-ination, and archiving of data for the mission. Source: EPO

EOS PROJECT The EOS Project Manager, his staff, and all other participants in the EOS Program who are located at GSFC. Source: EPO

EOS PROJECT MANAGER The GSFC official who has overall responsibility for executing to completion the design, development, test and operation of the EOS Program within a given set of boundary conditions (technical, cost, schedule, and organization approach). The senior individuals in subordinate installations may also be titled Project Managers, but they are responsible to the GSFC Project Manager. Source: EPO

EOS PROJECT SCIENTIST The NASA field center or U.S. academic institution scientist assigned to the EOS mission to manage its scientific aspects. The roles and responsibilities of this function are described in NMI 7100.11. Source: EPO

EPHEMERIS A tabular statement of the spatial coordinates of a celestial body or a spacecraft as a function of time. Source: EPO

EPHEMERIS DATA See ORBIT DATA.

FACILITY INSTRUMENT An instrument defined by NASA as having broad significance to the EOS Program that is provided by a designated NASA center or foreign agency. Source: EPO

FORWARD LINK DATA Instrument control and spacecraft control data. Source: EPO

GRANULE The smallest aggregation of data which is independently managed (i.e.., described, inventoried, retrievable). Granules may be managed as logical granules and/or physical granules. Source: ESADS, EPO

GROUND NETWORK (GN) The network of ground stations that support near-Earth spacecraft primarily in the launch or early mission phase. The Ground Network is the successor to the NASA Satellite Tracking and Data Acquisition Network (STADAN). Source: EPO

HOUSEKEEPING DATA The subset of engineering data required for mission and science operations. These include health and safety, ephemeris, and other required environmental parameters.

IN-SITU DATA Data associated with reference to measurements made at the actual location of the object or material measured, in contrast with remote sensing (i.e., from space). Source: EPO

INSTITUTIONAL FACILITIES OR ELEMENTS Facilities established by an institution that take on some responsibility in support of EOSDIS, or elements of the EOSDIS that function as part of an institution, and represent both EOSDIS and the programs, goals and purpose of the institution. Source: EPO

INSTRUMENT An integrated collection of hardware containing one or more sensors and associated controls designed to produce data on an environment. Source: ESADS.

INSTRUMENT CONTROL CENTER (ICC) An EOS facility dedicated to a specific instrument that plans and schedules instrument operations, generates and validates command sequences, provides the capability to forward commands and to store them for later transmission, monitors the health and safety of the instrument, and provides instrument controllers with status information of their instrument. Source: EPO

INTEGRATED LOGISTICS SUPPORT (ILS) The disciplined, unified, and iterative approach to management, engineering and technical activities necessary to plan and direct support considerations into every aspect of system development and operation. Regardless of organizational assignment or functional allocation, the discipline of ILS is the integration of multiple technical disciplines that address the support aspects of a system. The integration of all system elements is necessary to provide support at minimum life cycle costs.

INTERDISCIPLINARY SCIENTIST An individual selected by the project and/or the peer review process who is responsible for conducting investigations requiring analysis, interpretation, and use of data which crosses instrument and discipline boundaries. Source: ESADS

INTERNATIONAL PARTNERS Signatories of the Space Station MOUs that established the initial funding for the International Polar Platforms program to monitor Global Change, including NASA, ESA, Japan, and Canada. Source: EPO

INVENTORY A uniform set of descriptions of granules from one or more data sets with information required to select and obtain a subset of those granules. Granule descriptions typically include temporal and spatial coverage, data quality indicators, and physical storage information. An inventory may describe physical granules, logical granules, or both, including a mapping between them if they are not identical. Source: IWGDMGC, ESADS, EPO

INVENTORY CHARACTERIZATION Enhanced content-based metadata describing granules or aggregations of granules (phenomenology data bases, super- granules, feature tags, etc.).

INVESTIGATOR An individual who is contracted to conduct a specific scientific investigation. See also PRINCIPAL INVESTIGATOR and SCIENTIST.

INVESTIGATOR WORKING GROUP (IWG) A group made up of the principal investigators and research instrument team leaders associated with the instruments on a single spacecraft. The IWG defines the specific observing programs and data collection priorities for a single spacecraft based on the guidelines from the IWG.

LOGISTICS The science of management, engineering and technical activities concerned with requirements, design and supplying and maintaining resources to support objectives, plans and operations.

LONG-TERM INSTRUMENT PLAN (LTIP) The plan generated by the instrument representative to the spacecraft IWG with instrument-specific information to complement the LTSP. It is generated or updated approximately every six months and covers a period of up to approximately five years.

LONG-TERM MISSION PLAN (LTMP) The plan generated by the FOT that presents an integrated, operationally compatible spacecraft, instrument, EOSDIS, and institutional service plan that supports short-term planning and scheduling..

LONG-TERM SPACECRAFT OPERATIONS PLAN (LTSOP) The plan generated by the FOT that outlines anticipated spacecraft subsystem operations and maintenance, along with forecast orbit maneuvers from the Flight Dynamics Facility, spanning a period of several months. Each LTSOP is consistent with the associated LTIP and with mission specific information provided by the flight project.

LONG-TERM SCIENCE PLAN (LTSP) The plan generated by the spacecraft IWG that establishes guidelines, policy, and priorities for its spacecraft and instruments. The LTSP is generated or updated approximately every six months and covers a period of up to approximately five years.

MAINTENANCE The process of planning and executing life cycle maintenance concepts and requirements necessary to ensure sustained operation of system elements.

METADATA 1) Information about a data set which is provided by the data supplier or the generating algorithm and which provides a description of the content, format, and utility of the data set. Metadata provide criteria which may be used to select data for a particular scientific investigation. 2) Information describing a data set, including data user guide, descriptions of the data set in directories, and inventories, and any additional information required to define the relationships among these. Source: ESADS, EPO, IWGDMGC.

ORBIT DATA Data that represent spacecraft locations. Orbit (or ephemeris) data include: geodetic latitude, longitude and height above an adopted reference ellipsoid (or distance from the center of mass of the Earth); a corresponding statement about the accuracy of the position and the corresponding time of the position (including the time system); some accuracy requirements may be hundreds of meters while other may be a few centimeters. Source: EPO

OTHER USERS Those persons requesting data for scientific, operational, applications, or commercial use, who are not directly represented by an EO-ICWG member, and who agree to the stipulations on data access and use as set by the EOICWG and the EOS Program.

PATHFINDER DATA SET A long-term, global Earth science data set produced from non-EOS data using community consensus algorithms as part of the EOSDIS Program. Selection of Pathfinder Data Sets is made by the EOS Program Office (in consultation with the IWG and the science community). Source: EPO

PLAYBACK DATA Data that are stored on a spacecraft, platform, or other carrier that are transmitted at a later time. Source: ESADS

PRINCIPAL INVESTIGATOR (PI) 1) An individual who is contracted to conduct a specific scientific investigation. An instrument PI is the person designated by the EOS Program as ultimately responsible for the delivery and performance of standard products derived from an EOS instrument investigation. 2) The individual selected by proposal review, who has primary responsibility for preparing the proposal, selecting the investigation team, carrying out the scientific investigation, and reporting the results. Responsibilities often include supplying an instrument. Source: ESADS, EPO

PRODUCT ORDER Product order is either a request for the generation of a specific product with an associated time window, a priority processing request, a reprocessing request, or a standing order for a product to be generated on a regular basis with a rough timeline, or changes to standing orders. Product orders are received by the PGS from the IMS.

PRODUCTION DATA SET (PDS) Data sets generated by EDOS using raw instrument or spacecraft packets with space-to-ground transmission artifacts removed, in time order, with duplicate data removed, and with quality/accounting (Q/A) metadata appended. Time span, number of packets, or number of orbits encompassed in a single data set are specified by the recipient of the data. These data sets are equivalent to Level 0 data formatted with Q/A metadata. For EOS, the data sets are composed of: instrument science packets, instrument engineering packets, spacecraft housekeeping packets, or onboard ancillary packets with quality and accounting information from each individual packet and the data set itself and with essential formatting information for unambiguous identification and subsequent processing.

REAL-TIME DATA Data that are acquired and transmitted immediately to the ground (as opposed to playback data). Delay is limited to the actual time (propagation delays) required to transmit the data. Source: ESADS, EPO

RECONFIGURATION Any change in operational hardware, software, data bases, or procedures.

RESEARCH FACILITY INSTRUMENT An instrument provided and managed by an institution for use by a group of approved investigators. Data from the instrument may be made available for the operational applications. Source: ESADS

RETURN LINK DATA Spacecraft health and status data and instrument data. Source: EPO

SCIENCE COMPUTING FACILITY (SCF) A facility supplied by the EOS Program to an EOS TL, TM, or PI (Instrument or Interdisciplinary) for the following purposes: developing and maintaining the algorithms and software used to generate Standard Data Products; quality control of Standard Data Products; in-flight instrument calibration and data set validation; scientific analysis, modeling, and research; generation of Special Data Products; and use as an interface to the investigator's institutional facility. Source: EPO

SCIENTIST An individual having interest in the direct usage or support of the data which is collected and generated by, or the instruments which are contained within the EOSDIS. Included are principal investigators, co-investigators, research facility team leaders and team members, interdisciplinary investigators, instrument investigators, non-EOS affiliated science users, and other users of a diverse nature. See also INVESTIGATOR.

SPACE NETWORK (SN) The NASA assets required to communicate with Earth-orbiting spacecraft via the TDRSS. Source: EPO

SPACECRAFT The spacecraft is the EOS space or orbiting component composed of the payload and mission-unique equipment required to support the EOS mission. It includes propulsion, separation springs, and user interface equipment not unique to the launch vehicle. Source: EPO

SPECIAL DATA PRODUCTS See also DATA PRODUCTS. Products generated as part of a research investigation using EOS data and produced for a limited region or time period, or products that are not accepted as standard by the IWG and NASA Headquarters; they will be generated at research users' computer facilities. See also DATA PRODUCTS.

SUBSETTING Standard subsetting involves extraction of a multi-dimensional rectangular array of pixels from a single data granule, where consecutive pixels are extracted from each array dimension. For each dimension, the size of the pixel array is characterized by the starting pixel location and the number of pixels to extract.

SUPPORT EQUIPMENT All equipment required to support system operation and maintenance. This includes associated multi-use end items, ground handling and maintenance equipment, tools, calibration equipment, communications resources, test equipment and automatic test equipment with diagnostics software for both on-and-off equipment maintenance. It also includes the acquisition of logistics support for the support and test equipment itself.

TARGET OF OPPORTUNITY (TOO) A science event or phenomenon that cannot be fully predicted in advance, thus requiring timely system response or high-priority processing.

TEAM LEADER (TL) The person designated by the EOS Program as ultimately responsible for the delivery and performance of Standard Data Products derived from an EOS Facility Instrument. Source: EPO

TEAM MEMBER A person designated by the EOS Program to develop algorithms for Standard Data Products derived from an EOS Facility Instrument. Source: EPO

TELEMETRY A space-to-ground data stream of measured values (including instrument science data, instrument engineering data, and spacecraft engineering data) that does not include command, tracking, computer memory transfer, audio, or video signals. Source: EPO

TEST A procedure or action taken to determine under real or simulated conditions the capabilities, limitations, characteristics, effectiveness, reliability or suitability of a system or procedure.

TOOLKITS Collections of software and procedures to assist the user in performing computer-based activities relating to the EOS Program. Toolkits will be used, for example, to allow on-line access to DAAC data archives and to facilitate science data processing software development.

TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS) A constellation of NASA satellites and ground stations that track and relay data to and from low-altitude, Earth-orbiting satellites (including the Space Shuttle). This NASA system includes specialized communications satellites located in geosynchronous orbit both east and west of the continental U.S. (providing coverage of virtually the whole globe) and a TDRSS Ground Terminal at White Sands, New Mexico. Beginning in 1995, redundant Ground Terminals are scheduled to be in place at White Sands. Source: EPO

USER Any person accessing the EOSDIS. See also AFFILIATED USER and AUTHORIZED USER.